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PHYSIOLOGICAL
E S S A Y S
A N D
OBSERVATIONS,

B Y

JOHN STEDMAN, M.D.

FELLOW of the ROYAL COLLEGE of
PHYSICIANS in EDINBURGH.

EDINBURGH:

Printed for A. KINCAID & J. BELL, and T. CADELL LONDON,

MDCCLXIX.

ENTRANCE

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M. Wyman
May, 1893

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ESSAY I.
OF THE
DIVISIONS
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ESSAY I.

Of the DIVISIONS of PULSES.

AMONG the various signs of diseases, none are more frequently, nor more justly, attended to than those arising from the pulse; and though such may be, for the most part, insufficient by themselves to ascertain the nature of any distemper, yet we can seldom, with safety, proceed to the cure, without taking some indication from the state of the pulse.

OF the different conjectures which we are enabled to form from the pulse, the most obvious are, the increased or diminished velocity of the blood, when either of these are in a considerable degree; the changes in the action of the heart and arteries, and the comparative force of these organs. From the pulse likewise we are frequently enabled

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to draw indications relating to the quality of the blood. But those who have been most attentive to the symptoms of diseases, and are acquainted with the animal œconomy, will judge best of what importance an accurate examination of every circumstance relating to the pulse must be in the practice of medicine.

THE multiplicity of definitions, and the too minute divisions of pulses, have, instead of perspicuity, been productive of some degree of obscurity. Many authors have mentioned the GREAT, the STRONG and the FULL pulse indiscriminately, though these may be easily distinguished. It is hoped, therefore, that an attempt to correct these, with some other improprieties and defects in this part of pathology, will not be deemed unseasonable.

BELLINI, who hath written explicitly on this subject, makes the first division to consist of twelve kinds; or of six, each having

Of the Divisions of Pulses. 5

ing its opposite corresponding pulse: these are the PULSUS MAGNUS and PARVUS; FORTIS and DEBILIS; PLENUS and VACUUS; CELER and TARDUS; FREQUENS and RARUS; MOLLIS and DURUS.

SOME of these are seldom, if ever, expressed in English; for which reason they are here, and shall be throughout this essay, mentioned under Latin names.

WHEN we consider in what respects a pulse may deviate from its natural state, we shall thereby be led to make the first great and simple division: after which it will be easy to conceive what is meant by compounded pulses.

AN artery may differ from its natural action by being too much, or too little, dilated; or in its pulsations being too frequent or too slow.

It

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IT is evident that many divisions may be conceived, from the various dilatations of an artery, independent of the frequency of the pulsations; and likewise some from the frequency independent of the other. But, in making the first and simple division, it will be proper to distinguish, as much as possible, these different pulses by the greater or less frequency of the pulsations; that is, when the pulse exceeds, or falls below, its standard number in a given time. The reason is evident, when we consider, that we can be sure of the number of pulsations; whereas the various degrees of dilatation of an artery cannot be ascertained with such precision as to establish accurate divisions.

IT may be observed here, that, in mentioning the standard number of pulsations, it is not to be understood as if this could be restricted to a precise number. But if, in a matter so delicate, we can come within six, eight, or, in some people, ten pulsations, it will be sufficient for all the purposes wanted.

As

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As a deviation from the natural dilatation of an artery rarely, if ever, happens, at least from an internal morbid cause, without the pulse likewise changing from its standard number, we may, from hence, be led to deduce the four following pulses.

1. WHEN the artery, in its vibration, exceeds its natural dilatation, the number of pulsations being equal to, or falling below, the standard.

2. WHEN the artery falls below its natural dilatation, the number of pulsations being above the standard.

3. WHEN the artery exceeds the standard both in the dilatation and number of pulsations.

4. WHEN it falls below its natural dilatation, the number of pulsations being equal to, or below, the standard.

THE

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THE first of these I call the PULSUS MAGNUS; the second, the PULSUS PARVUS; the third, the PULSUS FORTIS; and the fourth, the PULSUS DEBILIS. The first of these differs from the second, and is opposite to it, both in the dilatation and number of pulsations; and the third differs from the fourth in the same respects.

THOUGH the differences in the dilatations of the artery, and the differences in the number of pulsations, generally, perhaps always, attend one another; yet, as the former are often wholly undistinguishable by us, we must therefore add to the first class the PULSUS FREQUENS and RARUS; that is, when the number of pulsations exceeds, or falls below, the standard, while the extension of the artery is, to our feeling, unchanged. Could we discover the various extensions of an artery with the same accuracy as we can reckon the number of pulsations, these two pulses, the FREQUENS and RARUS, might be neglected.

ALL

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ALL these pulses may be better conceived from the figure *, where $a b$, the distance betwixt the parallel lines, expresseth the difference betwixt the systole and diastole of the artery in the pulses described above: $a c$, the times: and the undulations, distinguished by the numerical figures, shew the number of pulsations in equal times. From the figure, this class of pulses may be conveniently compared with the mean or natural state of the pulse.

THE reason why the PULSUS FORTIS is thus distinguished from the PULSUS MAGNUS, will be obvious when we consider, that, in order to make the artery strike against the fingers with vigour, it is not only necessary that it exceed its usual dilatation, but likewise that the number of pulsations, in equal times, be increased.

WE may have a just idea of this from a pendulum; for, if the oscillations of the pen-

B

dulum

* Plate I. Fig. 1.

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dulum be wide, but slow, these correspond to the *PULSUS MAGNUS*. But, if the oscillations of the same extent be accelerated, these will give a proper idea of the *PULSUS FORTIS*: for the force with which the pendulum would strike against any resisting body is increased according to the degree of acceleration.

THE *PULSUS PARVUS* is so named from the diminished time of each pulsation, and likewise from the vibrations of the artery being more contracted than in a natural state. The *PULSUS DEBILIS* constantly indicates an unnatural weakness in the action of the heart. These two pulses are frequently mentioned indiscriminately: but, as they may be distinguished with ease and certainty, and as they correspond with propriety to the two preceding pulses, it is hoped that this division will be admitted.

THERE remains another kind of pulse in this division; this is when the artery, in the systole, doth not return to its natural state of
of

Of the Divisions of Pulses. 11

of contraction; or rather, when, in the systole, the diameter remains more extended than it ought. This is the PULSUS PLENUS; and, as it indicates a *plethora*, may properly be termed the plethoric pulse. In this case there seems likewise to be, for the most part, an uncommon dilatation in the diastole, and the artery is felt full, soft and obtuse, though its vibrations be feeble. The PULSUS PLENUS is so named, not from a great, or strong, vibration of the artery, but from the indication of an unnatural fulness in the vessel.

THIS pulse is often confounded with the PULSUS MAGNUS, as the learned M. de Haller observes; and yet they may without difficulty be distinguished: for the vibration of the artery, in the PULSUS PLENUS, is weak and confined, though the artery be really full and extended: whereas, in the PULSUS MAGNUS, the vibration is greater and more free. In the PULSUS

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PLENUS, the artery is frequently found to recover its elasticity by bleeding.

SOME authors, in the division of regular pulses, seem to think that each ought to have an opposite corresponding one. Thus, having described the PULSUS PLENUS, we find likewise a PULSUS VACUUS mentioned. But, upon considering the matter with great attention, I presume to think that there can be no such pulse distinct from those already described *.

FOR

* The Greeks, among other pulses, mention the Σφυγμός κένος. But it appears, that they did not understand by this, a low or empty pulse, as contradistinguished from the *pulsus plenus*. Thus Aretæus, in describing a beginning peripneumony, Lib. II. de acut. morb. Σφυγμοὶ τὰ πρῶτα μεγάλοι, κενοὶ, &c. Now the *pulsus magnus* and *pulsus vacuus* can never be supposed to coincide, in the sense in which the moderns understand the latter. By Σφυγμός κένος nothing more can be meant than a soft pulse, yielding readily to the touch, the artery feeling as if it were full of air rather than blood; such as that described by Galen in the same disease. ὁ δὲ περιπνευμονικῶν (σφυγμός) μέγας ἐστὶ καὶ κυματῶδες τι ἔχων ὃ ἀμυδρὸς ὃ μαλακὸς ὁμοίως τῷ τῶν ληθαργικῶν. &c. *Idagog. pulsuum.* The *pulsus vacuus* then of the ancients seems to have been the *pulsus plenus* of the moderns.

Of the Divisions of Pulses. 13

FOR, if we suppose the greatest degree of inanition, without destroying the action of the heart altogether, the pulse, in this case, will properly come under the denomination, either of the *PULSUS PARVUS*, or of the *PULSUS DEBILIS*, though, before this evacuation, it had been a *PULSUS PLENUS*.

IT hath been thought, in making these distinctions, that a pulse, which is defined from excess, whether in the quantity of blood, or in the action of the heart, ought to have an opposite pulse from an opposite cause *.

BUT we may observe, that an artery can admit of more divisions from its dilatations than from its contracted state: for the arteries are not supposed to contract beyond the systole, which is their natural state, or that
which

* Cum igitur unaquæque res dupliciter a naturali statu recedere possit, vel deficiendo, vel excedendo; omnis pulsus, a mediocri deficiens, vel excedens, appellabitur non naturalis. *Bel-lin. de puls.*

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which they assume when they suffer no violence. But their diameters may be extended beyond their natural degree, in the systole, as well as in the diastole, as is the case of a *plethora*; and, in so far, an artery may deviate from nature in more respects by excess than by defect.

It hath been observed, that the PULSUS MAGNUS and the PULSUS FORTIS denote much blood *. When these are understood as natural pulses, they may indicate that the vessels contain a sufficient quantity. But, when they indicate a morbid state of the body, they are the result of the quality, rather than of the quantity of the blood. It is true, that, in inflammatory cases, the disease may be moderated by bleeding, and is often cured by repeating that evacuation; but, in these cases, as the fever abates, the blood is observed to change its quality; and, when the disease is removed, the patient is found to

* Id. *ibid.*—Boerhaave *instit.* § 959. 961.

Of the Divisions of Pulses. 15

to be weakened in proportion to the quantity of blood lost. But, in true plethoric cases, one acquires strength and alacrity from the evacuation; which is the CRITERION of a true *plethora*, or a sign that the morbid cause lies solely in the quantity of blood.

THE PULSUS CELER and PULSUS TARDUS, are not supposed to relate to an increased or diminished number of pulsations in a given time; but to the artery receding more quickly, or slowly, from the fingers in feeling the pulse. These pulses seem not to differ from the MOLLIS and DURUS, but might be better expressed by OBTUSUS and ACUTUS, without any further distinction.

UPON the whole, the primary or most simple division of pulses consists of seven kinds, *viz* the PULSUS MAGNUS and PARVUS; FORTIS and DEBILIS; FREQUENS and RARUS; and the PULSUS PLENUS or PLETHORICUS.

ALL

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ALL these pulses, or the most part of them, are sometimes to be met with in the different stages of the same disease; but there are other diseases to which particular pulses are more peculiar. The PULSUS MAGNUS frequently attends a STUPOR, COMA, VERTIGO, LETHARGY, and other disorders of the head, where there is little or no fever. It is likewise not uncommon in HYPOCONDRIACISM and MELANCHOLY, and often presages a MANIA. In this respect the hypocondriacal disorders, in men, generally differ from the hysterical; as the latter are commonly attended with the PULSUS PARVUS: and, in general, the PULSUS MAGNUS is rarely to be met with in women; their manner of life and habit of body rendering the sex more liable to the opposite pulse.

THE PULSUS PARVUS is to be found in most part of fevers, either through the whole disease, or in some of the stages. Towards the end of inflammatory fevers, this
pulse

Of the Divisions of Pulses. 17

pulse is an unfavourable sign. It is a pathognomic sign in hectic fevers. The low, malignant, bilious and pestilential fevers are commonly attended with this pulse throughout. It is almost a constant concomitant of the PHTHISIS PULMONALIS. It is likewise common with women, who have weak nerves, and who are subject to sudden tremors, palpitations, and to the well known tribe of hysterical symptoms. In general, this pulse is more frequently met with than any other arising from morbid causes.

THE PULSUS FORTIS commonly introduceth inflammatory fevers, especially those proceeding from inflammations in the THORAX. This pulse, more than any other, indicates bleeding; being a certain indication of an increased velocity in the circulation, and frequently of a cohesive state of the blood. But though, in inflammatory fevers, attended with this symptom, we bleed with safety and advantage; yet there are fevers, in some periods of which we meet

C

with

18 Of the Divisions of Pulses.

with this pulse, and then ought to be cautious of bleeding. This is the case in fevers of the remitting and intermitting kind, where the *PULSUS FORTIS* precedes critical sweats.

THE PULSUS DEBILIS always indicates a diminished velocity in the circulation, and is, of all kinds, the most dangerous; and the more so, if, with the diminished extension of the artery, the pulse fall considerably below its standard number; for the blood, not being sufficiently agitated, soon loseth its natural texture. This pulse is frequently unequal, and interrupted*.

I. S°. a man aged about fifty five years, of a slow speech, and slow in all his motions, whose profession and genius confined him to mechanical studies, and arithmetical computations,

* Qui pulsus has malignitatis notas omnes conjunctas habet, certum lethi signum est; neque talem hominem evasisse exemplum extat. Haller in institut. § 966.

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computations *, fell into a slow fever, attended with a deep STUPOR, from which the most stimulating medicines were insufficient to rouse him. His pulse, which, for the first day or two, had been strong and frequent, for thirteen days afterwards, in the course of the disease, did not exceed forty eight in a minute; which, for such a length of time, was the slowest pulse I had ever felt. Though the pulsations were not very small, I was informed by the surgeon, that they were somewhat smaller than in a natural state; and that, in health, his pulse used to beat about sixty five in a minute.

ABOUT two days before death, his pulse became lower and more frequent; and both it and other symptoms soon gave evidence of a resolved state of the blood.

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SUPPOSING

* These characters are particularly mentioned, as I have frequently observed that people of this constitution are subject to disorders of the head, attended with a slow pulse,

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SUPPOSING then the artery, when beating so flow, to have lost, in the diastole, one tenth of its natural diameter ; and that, in the systole, there remained seven tenths ; then was the velocity of the blood in the disease to that when in health, as twenty-three to fifty one. Had there been no difference in the dilatation of the artery, the proportion, depending only on the number of pulsations, would have been as eight to eleven. But though we suppose the artery to have lost only so much of its extension as, with the diminished number of pulsations, to have made the circulation in the disease, to that in health, as thirty to fifty one ; there is reason to believe that even this would have been insufficient to preserve the proper texture of the blood for any considerable time.

IN this case, we have an example of the pulse passing from a natural state to the PULSUS FORTIS, from that to the PULSUS DEBILIS, and from that again to the PULSUS PARVUS. It may be observed
that,

Of the Divisions of Pulses. 21

that, though the number of pulsations in the *PULSUS PARVUS* may sometimes balance the loss of dilatation in the artery, so as to preserve the same degree of velocity in the circulation; yet this pulse seems always to indicate, either the weakness, or the labour and difficult action of the moving power.

THE PULSUS PLENUS is frequently met with in women, when the periodical return of the *MENSTRUUA* approacheth; particularly in those women who menstruate with difficulty. This pulse is likewise to be found in people of a thin habit, and pale complexion, subject to hemorrhages, whether from the nose, lungs, or hemorrhoidal vessels.

THE PULSUS PLENUS, not being distinguished by any increase or diminution of pulsations, may be attended either with a quick, or slow circulation, and therefore could not be well expressed in a figure.

HAVING

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HAVING thus proposed the great or primary division, it will be easy to refer the rest of the pulses to it, so as to distinguish what hath been called the compounded pulses. Thus, the MOLLIS and DURUS, CELER and TARDUS, ACUTUS and OBTUSUS *, DICROTOS, INTERMITTENS or INTERCURRENS, may fall in with any of the pulses described above.

MANY names have been affixed to pulses, which are merely figurative, and may well be dispensed with. Thus, the PULSUS FORMICANS, or fluttering pulse, is nothing but the

* The pulses *durus* and *mollis*, *celer* and *tardus*, *acutus* and *obtusus*, which may be considered as not differing from one another, may be conceived from figure 2. plate 1. where, if *a c* represent the surface of an artery in the diastole, the numbers 1, 2, 3, will give an idea of the *durus*, *celer*, or *acutus*; and 4, 5, 6, of the *mollis*, *tardus*, or *obtusus*. These pulses, being distinguished by the proportions of time betwixt the *systole* and the *diastole* in each pulsation, may coincide with any of the pulses in the first division, which are all distinguished, either by the velocity of the pulse, or by the dilatation of the artery differing from a natural state, or by both these together; to which two distinctions the three pulses here described have no reference.

Of the Divisions of Pulses. 23

the PULSUS PARVUS in its lowest state; the VERMICULARIS is the PULSUS DEBILIS; the PULSUS UNDOSUS is that kind which is said to be felt fuller under one finger than another; but which cannot be owing to any difference in so small a portion of an artery, but either to the greater pressure of one finger than of another, or to one part of the artery lying more superficial, or deeper, than another. This kind, therefore, as well as the PULSUS MYURUS and CAPRIZANS, seem to be only a deception. But every kind of pulse, having some resemblance to a wave may, without impropriety, be termed UNDOSUS. Now, as the idea of some of these pulses appears to have arisen from an unequal application of the fingers to the radial artery, the method of feeling pulses to the greatest advantage, may not be unworthy the attention of young practitioners.

AN artery being but a very little more or less superficial gives the idea of a strong, or of a weak pulse: hence it is, that, in the
same

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same person, we often feel the pulse in one arm different from that in the other; and Boerhaave justly observes that the pulse is frequently deceitful in fat people *.

WHEN the pulse is not distinct, the most certain method of judging of it is, to press the fingers so much that the circulation in the artery may seem to be stopped; and, raising the fingers gradually, let the touch at last become quite superficial. By this method we may judge with more certainty of the action of the artery, than by an uniform pressure of the fingers: and as, in feeling the pulse, when our fingers are cold, we are apt to believe the pulse to be weaker than it really is, it is of some consequence to preserve the natural heat of the hand.

It hath been believed, that there is an exact proportion between the quickness of the circulation and animal heat; or that
the

* Boerhaave institut, § 960.

Of the Divisions of Pulses. 25

the degree of heat increaseth in proportion to the attrition, and *momentum* of the blood; and the pulse, being the only indication of changes in the circulation, hath likewise been believed to indicate greater or less degrees of animal heat *.

WHETHER those, with whom the natural *momentum* of the blood is greatest, be likewise possessed of the greatest degree of vital heat, in the sense in which the ancients understood vital or internal heat, I shall not pretend to determine. But we now know that nothing more was understood by this, than the principle of life, in an higher, or lower degree, independent of real or absolute heat.

BUT though the constitutions of animal bodies be supposed to be, *ceteris paribus*, better, the greater the natural force of the moving power is, this hath no relation with absolute heat, or animal heat, taken in a

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literal

* Boerhaave Institut. § 968.

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literal sense, which doth not appear from observation to depend upon the *momentum* of the blood, attrition, or the resistance occasioned by the density of the fluids; for it is known from experiments, that the heat of the human body is frequently above the standard, while the *momentum* of the fluids is considerably below its natural state; particularly when the texture of the blood is so much resolved that we have reason to believe the resistance at the capillaries is less than usual. This is, for the most part, found to be the case in the last stage of putrid, bilious, and pestilential fevers.

PROFESSOR de Haen observes, that the *momentum* of the blood, or attrition, is so far from being the cause of animal heat, that, even after the motion of the fluids hath ceased altogether, heat hath been found to increase; and accordingly observed the thermometer to rise when applied to human bodies immediately after death. When the thermometer is suddenly exposed to heat of a considerable

siderable degree, the mercury is observed to fall a little, and then to rise. The glass ball of the instrument being somewhat enlarged by the heat, before it hath had time to act upon the mercury, is the cause of this descent. For the same reason, when the instrument begins to cool, the ball is contracted before the mercury hath lost any degree of its rarefaction, and, consequently, it will ascend in the tube, even while the ambient heat diminisheth *. This experiment therefore, meant to prove the increase of heat after death, would have been more satisfactory, had the learned author signified that he was aware of these effects of heat and cold on the thermometer.

It is not improbable that heat, whether of itself a positive body, or merely the modification of other bodies, may be possessed of different qualities, as well as it is suscep-

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tible

* This hath been ascertained by various experiments, particularly by those of Bulfinger. Comm. Acad. Petropolitana. vol. 3. p. 242.

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tible of different degrees. Those who have been accustomed to touch sick people, especially when under the species of fevers last mentioned, must have been sensible of a pungent heat, affecting the fingers in a manner different from the heat of the body when in health, though then raised to an high degree by exercise, or otherwise. Galen was particularly attentive to this circumstance, and describes the difference betwixt a vital or natural, and a morbid heat, as a symptom of great consequence*.

THE pulses hitherto described are meant as indicating a morbid state of the body, and are supposed to refer to every person's natural pulse; for what is a natural pulse with one person, may indicate a morbid state

* Siquidem est substantia caloris genuini (τῷ ἐμρῳτῷ θερμῷ) temperata; ignea adventitii (τῷ ἐπικτῳτῷ.) Sanorum enim calor vaporosus est, blandus, et ad tactum familiaris, gratusque, nihil quod molestum, asperumve, et mordax sit, habens. Contra febricitantium calor, præsertim si febris sit hæctica, aut ex humorum orta putredine, acris, ingratusque est, mordax etiam, ac tangentem manum pertundens, atque pungens. Galen in Hippocrat. Aphorism. 14. sect. 1.

Of the Divisions of Pulses. 29

state of the body with another. One of a gigantic size, and of an athletic habit, hath not naturally the same kind of pulse with a dwarf; nor can either of these be supposed to have a pulse equal to that of the other, without a disease; and we often meet with people, seemingly of the same habit and constitution, who have nevertheless pulses of different kinds; from which it appears of what advantage it is to be acquainted with the constitutions of people in health, to be able to judge with greater certainty of the nature of diseases.

BUT, when one is said to have naturally a great or little, a strong or weak, a quick or slow pulse, these are supposed to refer to an universal mean pulse; an idea of which every physician must form to himself, from a frequent examination of a variety of pulses. Thus, when Boerhaave says that the pulse which is strong, great and slow, is, of all kinds, the best, we must understand this as referred to an universal mean pulse, or the
expression

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expression can have no meaning: for where any person's pulse is said to be great, strong and flow, with respect to the mean or natural state of that person's pulse, then are we to understand these characters of the pulse as indicating a morbid state of the body.

ESSAY II.

ESSAY II.

OF

MENSTRUATION.

ESSAY II.

OF MENSTRUATION.

THE monthly evacuations of women being one of the most curious circumstances in the animal œconomy, several learned physiologists have exerted themselves to account for them. Some would ascribe them wholly to a periodical addition of blood, without admitting any change in its quality, while others would have them proceed from a fermentation, or some other change in the fluids.

DOCTOR Freind, among others, having treated this subject with his usual elegance and perspicuity, and his hypothesis having been generally adopted, I shall here examine, (though with the regard that is due to the memory of so respectable an author,) whether his

E method

method of accounting for the menses by mechanical laws be sufficient, and agreeable to the operations of nature ; or what other principles can assist us in explaining this branch of the animal œconomy.

I. A MONTHLY PLETHORA, arising from a defective perspiration, is the ground work of Doctor Freind's hypothesis. But it doth not sufficiently appear, whether the learned author means that a greater proportion of blood, and a less proportion of perspirable matter is generated in women than in men ; or, supposing the proportion to be the same in both, whether the discharge by the pores of the skin be less in the female sex than in the male.

THAT this last was Doctor Freind's opinion, appears more probable from several passages in his *Emmenologia*, particularly where he quotes the fifty second aphorism, sect. 1. of Sanctorius, in support of his own hypothesis, viz. that want of strength is a cause
of

of a defective perspiration; that the force of the heart in females, being less than in males, is insufficient to discharge all the perspirable fluid, and that the quantity retained proves the cause of a periodical PLETHORA*.

ACCORDING to Doctor Freind, the quantity of the monthly discharge may amount to about twenty ounces †. Hence one thirtieth part of this quantity, or even of two pounds, every day, comes to be but an inconsiderable diminution of perspiration, and will sufficiently account for the monthly PLETHORA ‡.

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THAT

* Quid enim est robur, nisi vis illa quæ a sanguine et spiritibus in membra derivatur? ea vero quomodo derivari potest, nisi cor validius contrahatur?—Ad hunc modum a viribus imbecillis orietur perspirationis defectus. Emmenol. cap. 3.

† According to others, particularly Sydenham, it is much less. Astruc makes it extend from 8 to 16 oz. De Haen from 4 to 10, or 11.

‡ Igitur satis esset sanguinis plethorici ut lib. 1. $\frac{2}{3}$ quæ vulgaris est catameniorum mensura, singulis mensibus effundi possit, si non ultra 5 $\frac{2}{3}$ drachm. quod perpaucillum est, per diem imminueretur perspiratio. Emmenol. cap. 7.

THAT there is a redundance of blood every month is abundantly evident. But that the cause of this PLETHORA is a deficient perspiration, may be called in question for the following reasons.

I. THE quantity of perspirable matter retained in the blood every day, according to the above computation, being only 6.4 drachms, cannot be supposed to produce bad consequences, provided it be not retained in the body many days. But, if this quantity goes on accumulating to two pounds, or nearly so, in thirty days, it cannot fail to have bad effects, long before the expiration of that time, according to all the accounts we have of obstructed perspiration. Sanctorius every where declares the danger of a stopped perspiration, and says, that twelve ounces, (which is little more than one half of the above-mentioned quantity,) retained in the body for twenty four hours only, must either be discharged by some sensible,

fible, and critical evacuation, or quickly occasion a disease *.

2. IF the final cause of the PLETHORA in women be the nutrition of the foetus, as hath been generally believed, it is not probable that nature, in order to attain this end, would have recourse to a real defect, that is, the want of power to expel an excrementitious fluid. Nor can we well believe that this same fluid, which is found to be so hurtful to the body when retained in it, can be the source of milk, a nourishment so necessary for children after birth.

3. IF Doctor Freind considers the menses as the effect of diminished perspiration, it might naturally have been expected, that, in order to make one part of his hypothesis square with another, the learned author would have supposed, with some others, that this monthly evacuation is the means of purging the blood; whereas he says that the
menstrual

* Sect. 14. aphor. 31. and 37.

menstrual fluid is the purest, and most fragrant arterial blood *.

4. WHEN women come to that term of life, in which the menses cease, as the vital functions then become weaker, the power of carrying on perspiration must likewise diminish: this both Sanctorius and Dodart found by statical experiments †.

IN what manner then can we suppose the perspirable matter to be disposed of, at a period of life when an outlet ought to be more necessary than ever? If it be said, by stool, or urine; why not by these channels before? If it be not carried off at all; then ought women, in the latter part of life, to increase in weight at the rate of 16, or 20 ounces every month: which is so far from being true,

* Neque enim in sanis sanguis ille qui ejicitur impurus est, aut vitiosus, sed optimus et fragrantissimus.

† Sensim enim ab ætate constanti et integra, ad ætatis flexum minuitur perspiratio, et quo magis ingravescit ætas, eo minor fit evacuatio. Dodart Medicin. Stat. Gall.

true, that, for the most part, they diminish after that period.

WE are told of women, in the most northern inhabited latitudes, who do not menstruate in winter, having that evacuation only during the summer*. According to Doctor Freind's theory, it ought to be quite otherwise; since it is found, by statical experiments, that we perspire more in summer than in winter; and, in these cold climates, the difference of perspiration, in the two opposite seasons, must be considerable.

IT would therefore seem preposterous to suppose, that the passages by which the vessels used to unload themselves should be shut up, when the necessity for the discharge increaseth.

UPON the whole, since a greater quantity of blood is necessary in females than is sufficient for nourishment, it appears more analogous

* Linnæi Flor. Lapon. p. 324.

logous to the other operations of nature, to have endued them with a greater power of making blood than the males: and, as a larger proportion of blood is generated, the perspirable, as well as all the sensible evacuations, must be proportionally less.

II. THE next thing to be considered is a PLETHORA, and its effects on the circulation. Doctor Freind observes that, in a PLETHORA, the animal spirits are increased, by which means the action of the heart becomes stronger; and, in consequence of that, the velocity of the blood is likewise increased.

THAT there is always an addition of animal spirits, upon an increase of blood, may be doubted: for those, who labour under a PLETHORA, seem not to gain, but rather to lose animal spirits; for, in this state, it is commonly observed that we become more sluggish, and not more active.

THAT

THAT the secretions may be regularly carried on, there ought to be a just quantity of blood. If its velocity be increased, and if, at the same time, there be too great a proportion of it, then is it probable that the *impetus* on the glands, being greater than it ought, will prove the cause of crude secretions; and that this may be the case with the brain, as well as with the other glands, we have no reason to doubt.

NOR is it likely that the perspirable matter retained should furnish fresh supplies of animal spirits: and this agrees well with what Doctor Freind observes in another place, *viz.* that, about the time of menstruation, women are affected with a *languor*, from the too great weight of the body, and from the dilatation of the finer blood vessels of the brain, whereby the passage of the nervous fluid into the nerves is obstructed, and hence the members of the body are

F deprived

deprived of their due quantity of animal spirits *.

BUT, however plausible this reasoning may appear, it is to be presumed, that, in a PLETHORA, *cæteris paribus*, the velocity of the blood will not be increased, but, on the contrary, will be diminished.

To preserve the animal œconomy, a certain *ratio* betwixt the quantity of blood, and the elastic power of the heart and arteries, is necessary: so that an additional quantity of blood is not always to be supposed necessary to constitute a PLETHORA; for this state may arise as well from the diminished force of the heart, the quantity of blood remaining unchanged, as from an increased quantity of blood with the same force of the heart. Thus, in consumptions, the solids

* Languor vero invadit, quia in plethora nimio pondere laborat corpus, et tenera cerebri vascula ita turgescunt, ut compressu suo, omnes pene in nervos aditus præcludunt, hinc in membra minor derivatur spirituum copia. Emmenol, cap. 8.

lids wasting, and the heart becoming weaker, occasion a PLETHORA, the proportion of blood being too great for the force of the heart; so that bleeding, by restoring the balance, gives a temporary relief to the patient; and the power of the heart still diminishing, the same evacuation becomes again necessary. But in this essay, a PLETHORA is to be understood as proceeding from an increase of blood.

THE natural state of an artery is supposed to be its systole: any degree of extension beyond this state is owing to force. When there is a redundance of blood, it is to be believed that the arteries cannot return entirely to their natural state, but must suffer some degree of extension even in the systole. This, as I said, we must call a PLETHORA, in the strictest sense, and seems to be the simplest idea we can form of a PLETHORA arising from a redundance of blood. For, could the arteries act with a full vibration, and return from their diastole to their natu-

ral state with entire freedom, it could not be said that there was more blood in the body than just enough.

It hath been found that a small difference in the dilatation of an artery requires a great number of pulsations to compensate it. And as, in a PLETHORA, the vibrations of the arteries must be more confined than usual, a proportional acceleration of the pulse becomes necessary to preserve an equal degree of velocity in the blood; but, to increase the velocity of the blood to any considerable degree, the pulse must be greatly accelerated.

Thus, it is evident that the heart and arteries act with great disadvantage in keeping up a due degree of velocity in a redundancy of blood; and if there be any additional stimulus, whether from an increase of animal spirits, or otherwise, the effect will not shew itself in the contraction of the arteries, (fluids being of too incompressible a nature

nature to admit of that,) as in the acceleration of the pulse.

IT appears further from common observation, that, when there is a general PLETHORA near the time of menstruation, (which is the case with some women about that period,) the circulation is slower than usual. For, besides that there is then either no acceleration of the pulse at all, or an inconsiderable one with women otherwise in health, the vibrations of the arteries are generally observed to be more confined than when there is no PLETHORA. And it hath been found that the arteries are relieved, and recover their elasticity, by bleeding in a PLETHORA. We shall see afterwards that this is wisely ordered, since the eruption of the menses is safely brought on by an increased quantity of blood, and a diminished velocity, and that this discharge could not have happened without danger had there been an increase of both.

III. THUS

III. THUS far with respect to the effects of a general PLETHORA upon the circulation. But when we come to consider the structure, number, and disposition of blood-vessels belonging to the UTERUS, and neighbouring parts, it will appear that every thing is contrived, not only to prevent the rapid motion of the blood, but to make the circulation in these parts remarkably slow, even with a common quantity of blood, but much more so in a PLETHORA.

THAT this may appear the better, we are to consider that the capacities of any number of branches coming off one trunk, when taken together, being greater than the capacity of that trunk, the motion of the blood in these branches will be proportionally slower than that in the trunk. Thus, if six branches come off one trunk, and if the diameter of each branch be two thirds of that of the trunk, then will the velocity in the branches be to that in the trunk as three to eight, the capacities being as the squares

squares of the diameters, and the velocity reciprocally as the capacities.

THE blood sent to the UTERUS, OVARIA, and VAGINA, is conveyed in the hypogastric, and spermatic arteries, of which two vessels the ramifications are very remarkable for number and size: for not only a great many large branches are spread every where upon the UTERUS *, and VAGINA; but the LIGAMENTA ROTUNDA are little more than a *congeries* of blood vessels.

WE cannot pretend to form a conjecture about the size and number of these branches, in proportion to the trunks from which they are derived; and, consequently, what the precise *ratio* of the velocity in the branches to that in the trunks may be: but it is evident, in general, that the motion of the blood in these parts must be very slow †.

HAD

* Uterus arteriarum et venarum tela est et complicatio. Haller prælect.

† Doctor Keil found by an accurate mensuration, and computation, that the velocity in the thirtieth branching from any trunk is to the velocity of the blood in the trunk as unit is to 615.

HAD an extraordinary velocity of the blood been necessary to produce the monthly eruption, the blood would have been conveyed to these parts by many trunks; and these trunks would have been large in proportion to their branches.

BUT when we find the circumstances quite different, that is, few and very moderate trunks, with large and numerous ramifications, we must conclude that nature hath intended that there should be a very languid circulation in these branches.

BESIDES the slow circulation, the accumulation of the blood in the uterine vessels, in a PLETHORA, is readily accounted for by attending to the three following circumstances.

I. IN animal bodies, the coats of the arteries are, in general, found to be thinner, and weaker the more these vessels are ramified,

fied, and the further they are removed from the original trunk.

2. THE larger the diameter of any artery is, or the greater its capacity in proportion to the thickness and strength of its coats, or to its elasticity, the less will the power of that artery be in carrying on the circulation.

3. THE more susceptible any artery is of a great and sudden distension from a minute and contracted state, the weaker must that artery be.

By comparing the numberless ramifications, and remarkable size of the uterine vessels with what hath been said above about a PLETHORA, it appears that the elastic power of these vessels must soon yield to any additional force; and, consequently, that, in a PLETHORA, there must be an uncommon determination of blood to these parts, and a collection of it there. To this likewise

the serpentine disposition of the vessels contributes not a little.

THE arteries of the UTERUS, before puberty, or soon after menstruation, are so small as to be invisible, and do not admit red blood: but about the time of the eruption they are greatly distended*. This expansion being so sudden, the elastic power of these arteries must be very inconsiderable, when compared with that of the other arteries of the body of the same size, whose growth hath been slow, and in proportion with that of the body.

BUT it may be further observed, that the spermatic vein, being large in proportion
to

* De Graaf tells us, that, in a woman whom he dissected, near the time of menstruation, he found the uterine vessels enlarged to such a degree as to admit his finger. The elastic power of the arteries in such a state must be almost entirely overcome.

Maxima arteria uteri non distenti, invisibilis est, si cum arteria rubra comparatur: et hæc tamen invisibilis arteria, adeo magna fit in utero pregnante, ut initium calami scriptorii admittat. Haller. prælect.

to the artery, and having no valves, must resist the action of the arteries; since the column of blood in the vein is large, is to be raised almost perpendicularly, and is not supported by valves.

THESE observations would seem abundantly to shew how every thing is contrived to collect a great proportion of blood in the uterine arteries in a PLETHORA; and, by comparing all circumstances, it is evident that, as the time of the menstrual discharge approacheth, the circulation must be extremely slow in the larger vessels of the UTERUS; and, if so, its motion in the finer branches, whose orifices open into the UTERUS and VAGINA, must be inconceivably languid: or, which is not improbable, there must be an absolute stagnation in these ramifications for some little time before menstruation.

THE effects then of a very slow circulation, or of a stagnation of the blood in

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any part of the body, comes next to be considered.

IV. To preserve the texture and soundness of the blood, a due degree of velocity, according to the size of the vessels, is requisite. When this fails, and the motion of the blood becomes much slower than it ought, it is observed to change its nature.

It hath been found that blood out of the body, and kept in the degree of animal heat, doth not coagulate, but soon tends to a putrid and dissolved state*.

THE *halitus*, too, which flies off when blood is exposed to the air, being the most putrescent part of it, must promote this tendency to putrefaction more while in the body than when out of it.

FROM this we may judge what change the blood undergoes in the body, when the circulation

* *Theses de sanguinis separatione spontanea*, Auct. Martin. Butt.

circulation fails, or becomes so slow as to be next to stagnation: for the blood being pent up in the uterine vessels, and the circulation being slowest, or probably ceasing in the last ramifications of the arteries, that is, in these which open into the cavity of the UTERUS and VAGINA, this blood, I say, in them, must tend to a dissolution; and, by putrefying, must contract an acrimony sufficient for irritating the containing vessels, while the impulse from behind still increaseth.

THESE two causes, co-operating, must at length produce an oozing from the uterine arteries into the cavity of the UTERUS and VAGINA; and this effect must continue so long as the cause; that is, till the PLETHORA cease; the uterine vessels collapse or recover their tone; and till a due degree of velocity be restored to the fluids passing through these organs.

It

It may not be improper to observe here the analogy between the menstrual and hemorrhoidal flux, especially in those with whom the latter is periodical. As the vessels in the RECTUM gradually swell, the blood circulates slower in that part, and at length stagnating there, an acrimonious *ichor* then transudes, and, with some, blood breaks out, and continues to ooze till the vessels be sufficiently emptied.

OTHERS, whose blood is of a looser and weaker consistence, and its quality acrimonious and scorbutic, have large and obstinate hemorrhages this way; and women of the same constitution are no less subject to immoderate floodings from the UTERUS.

IN this manner is the menstrual flux carried on gently and safely: whereas, had a PLETHORA, and an increased velocity of circulation combined to make an eruption of arterial blood, it could not have happened without a sudden and dangerous hemorrhage;

morrhage; as is known to be the case when the blood finds vent through the arteries where the circulation is rapid.

AFTER impregnation, the blood, going to form the foetus and secundines, circulates through both in the same manner as through the mother; and, having its due degree of motion, undergoes no change in its quality.

UTERINE hemorrhages, after impregnation, are justly reputed dangerous: and yet it is well known that many women continue to menstruate two or three times, or oftener, after impregnation. Whether the vessels communicating with both the UTERUS and VAGINA, and passing from the one to the other, are intended to relieve the UTERUS, by throwing off part of the blood through the sides of the VAGINA, when there is more than is necessary for the nourishment of the embryo, I leave to others to determine.

THE *nausea*, to which most women are subject during the first weeks of impregnation, seems also to be a wise intention of nature. For, as they are able to take but little food, while in this condition, less blood is proportionally generated, the derivation of blood to the *UTERUS* must likewise be less, and, consequently, there must be less danger of hemorrhages from the uterine vessels, and of abortion from that cause.

IT may be objected, that the menstrual flux, according to Hippocrates *, Doctor Freind †, and others, consists of the finest and purest arterial blood.

BUT this doth not follow because it comes immediately from the arteries. Blood, if deprived of motion, and of a proper degree of conqassation, will contract a putrid and
acrimonious

* *Morb. Mulier. lib. 1. sect. 15.*

† *Sanguis ille qui ejicitur—ex capillaribus arteriis erumpit; ideoque naturam arteriosi, h. e. purissimi sanguinis retinet. Em-menol. cap. 2.*

acrimonious quality in the arteries, as well as in the veins: and, though it become somewhat more liquid than in a natural state, and contract a degree of acrimony, so as to irritate the containing arteries; yet still it may retain the florid appearance of pure blood. Nor can we conclude from the brownish, or dusky colour of the menstrual blood, that therefore it comes from the veins, as Astruc observes; since blood, becoming putrid from stagnation, or otherwise, contracts that colour*.

WERE the menstrual blood pure, and absolutely sound, then might it be expected that sudden obstructions of the menses, especially from external causes, as putting the legs into cold water, ought not to be productive of such troublesome consequences as commonly follow. These effects are known to be, for the most part, obstinate and untractable, continuing for many
H months,

* See Sir John Pringle's experiments on the blood.

months, sometimes for years, and are frequently attended with symptoms indicating the mass of blood to be tainted.

BUT if the menstrual blood hath contracted a degree of putridity, and the same acrimonious quality that is found to be the consequence of stagnation; then may this blood, in case of uterine obstructions, be supposed soon to affect the mass, and to produce the various evils which follow these obstructions. A small quantity of blood, tending to a putrid state, being taken up, and circulating with the fluids, instead of passing off by the natural chanel, may well be supposed to spread its noxious quality through the animal frame, or to fall upon some particular member.

IN this way the effects of these obstructions seem to be more naturally accounted for, than by supposing a few ounces extraordinary of sound blood to circulate through the body. A PLETHORA of this kind, we
may

may reasonably believe, ought to be corrected by bleeding. This evacuation, however, hath, for the most part, but little effect in removing disorders arising from obstructions of the menses.

WE are told, by several authors, of found blood being extracted from the UTERUS, after having been long confined there, by membranes obstructing the passage, or by some unnatural formation of the parts.

BUT, though this blood might still retain its fluidity, it doth not therefore follow that it was sound, and free from acrimony. On the contrary, there are, generally, circumstances mentioned, which prove blood thus retained to have contracted a greater, or less, degree of putridity.

ANTHONY BENEVOLI * extracted, from the UTERUS of a young woman, several pounds of blood which had been accumu-

H 2 lating

* *Dissertazioni et osservazioni*, p. 79, &c.

lating there upwards of three years; and observes that it was still so liquid as to pass through the catheter, but had contracted a dusky colour, and had the appearance of lees of wine.

RUYCH tells us, that, having extracted four pounds of blood from the UTERUS of a woman of twenty years of age, by piercing a membrane which totally obstructed the passage, he was surprised to find the blood neither coagulated, nor fetid; but observes that it was of a blackish hue*.

ANOTHER case is told † of a great quantity of blood discharged from the UTERUS of a young woman, by the incision of a similar membrane, where the blood is said to have been of a good colour, very fluid, and no ways fetid. But, being exposed to the air, it soon began to ferment, and flowed

* Observation. anatom. chirurg. cent. obs. 32.

† Holl. Maatschap. te Harlem. tom. 5. p. 424. & seq.

ed over the vessel, though its edge was three inches above the surface of the blood, when first put into it. This was a certain proof of a very high degree of acrimony, notwithstanding the appearance of sound blood when first discharged *.

THUS it appears, from different examples, that blood may remain long in the UTERUS without coagulating, though it lose the quality of sound blood ; and in so far these, and similar cases, strengthen this theory of menstruation, as likewise by shewing that the blood may be very acrimonious, and yet have the appearance of sound blood ; and further, that this blood, notwithstanding its putrid and acrimonious quality, may remain in the UTERUS a long time, without hurt to that organ. But this last circumstance might be

* Sanguis, incisa membrana hac, erumpens, boni coloris erat, admodum fluidus, et nullum spirabat foetorem : dum in vase receptus reponeretur, incepit rarefcere et fermentari, ita ut transcenderet marginēs vasis, quamvis illi tribus digitis transversis, eminerent supra contentum in vase sanguinem. V. Commentar. B. Van Swieten in aphor. Boerhaave 1290.

be proved from many examples, which shew the blood to have been putrid upon its first eruption *.

It was perhaps from some examples of this kind that the ancients had contracted the opinion of the baneful quality of menstrual blood. But, with women in health, according to this theory, an high degree of acrimony is not supposed: so much as to stimulate the vessels gently, and promote the fluidity of the blood, can hardly fail to bring on the discharge with greater advantage, than merely a plenitude of the vessels.

NOR is this state of the UTERUS to be deemed morbid, notwithstanding this acrimonious quality of the blood. For this change in the blood, being the necessary consequence of a defect of motion and agitation, it becomes an excrementitious fluid, and

* Hildan. centur. 3. observ. 60. exempl. 2. Saviard. observ. 4.—For some other examples see Smellies Midwifery, vol. 2. collect. 2.

and would infect the mass, were it again to be taken up, and to circulate with it, as the *saliva*, or urine, would affect the soundness of the blood, were they to be mixed with it, after having ceased to flow through the body with the general mass.

If it be objected, that an acrimonious and resolved state of the menstrual blood would endanger too sudden, or too great an eruption; it may be observed, that, even with women who have the menses so diluted as to appear pale, and like water tinged with blood, the discharge is frequently as gradual, as when the blood is of a better consistence.

Thus far the theory of menstruation seems to be a natural deduction of causes and effects. But there are some circumstances relating to the menses, the causes of which cannot be so easily traced; and particularly, why this evacuation doth not happen before the age of puberty.

THE

THE reason why the menses do not flow till this period, is commonly said to be, because the blood is expended in the increment of the body.

IT hath been observed, that, in the earlier periods of life, the solids, being soft and pliable, make less resistance to the momentum of the blood, and therefore admit of expansion and increment; but as the solids acquire a greater degree of firmness, they make greater resistance to the action of the heart, and force of the blood. And as women approach their full growth, more blood being still prepared than can be expended in any further increment, this excess must be disposed of in some other way; and the UTERUS, it is said, is a fit receptacle and emunctory for it *.

THE

* We may judge of the harmony of nature, in the oeconomy of female bodies, by comparing the quantity of the menstrual flux with the increment of the body, still making allowance for the uncertainty of a computation of this kind. Let a woman of fifteen years of age weigh 130 pounds, the mean increment of each month in fifteen years is 8.66 ounces.

THE reason why the body ceaseth to increase, after a certain period of life, hath been believed to be the firmness of the parts, and the resistance thereby made to the motion of the fluids.

BUT the true cause is different from this; nor doth it depend upon the firmness of the parts, that the body ceaseth to grow, but upon its size and weight in proportion to the force of the moving power. For, though the body were actually softer, and the parts more pliable at the age of puberty, or thereby, than when in a state of childhood, it would not increase, or but very inconsiderably, from that cause.

It may be observed that the universal law, with respect to the power and magnitude of machines, obtains likewise in animal bodies. Now, as the power of the first mover, in an animal body, increaseth in a lower *ratio* than the incumberance and resistance arising from the bulk and weight of

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the machine, independent of the softness, or hardness of its parts; therefore, so long as the moving power can do more than merely support the body, or keep up the motion of the fluids, so long will the body continue to increase. But when the weight or magnitude of the body comes to be a just balance on the heart, it will do no more than preserve the machine, by keeping up the circulation, without any further increment.

BUT though, about the age of puberty, the greater firmness of the parts should occasion a reaction from the more superficial parts of the body upon the internal organs, it doth not appear that this would be sufficient to produce the menses at that period. The firmness which the solids acquire, as the body encreaseth, is gradual; and the effect of the reaction of the fluids upon the uterine vessels ought likewise to be so: whereas the accumulation of blood in these vessels is sudden; the UTERUS being of a firm consistence, its vessels appearing to be totally
void

void of blood not many days before, and after menstruation, as hath been observed in the bodies of women who have been cut off by sudden or violent deaths. Besides, the body frequently continueth to grow remarkably after the first menstrual eruption, nor doth it appear that the menses are interrupted by this increment.

THOUGH therefore the above mentioned cause may co-operate, in some degree, with others; it is probable that there must likewise be a natural aptness, or disposition in the UTERUS to receive the menstrual blood, with which disposition it had not been endued before this time, like many other changes which happen to the human body at particular periods of life, of which none are more remarkable than those which both sexes undergo about the time of puberty, the causes of which we are frequently unable to discover.

WHETHER the lymphatic fluid in the milky vessels of the UTERUS, by acquiring a thicker consistence about the time of puberty, and so compressing the uterine veins, may thus force the blood through the APPENDICES VENOSAE, according to Astruc's hypothesis *, I shall not pretend to determine. But it doth not appear that the most expert anatomists have discovered sufficient foundation for this theory.

It remains now to enquire whether a general PLETHORA be necessary; or a partial one sufficient to produce the menses.

HAD all the arteries of the body been endued with an equal degree of elastic power, according to their capacities, in this case there could not have been any cause for a partial PLETHORA; for all the arteries acting with equal force, according to their diameters, must be supposed to have made an equal distribution of the blood: nor could there

* *Maladie des femmes.*

there have been any reason why a greater collection should be in one part of the body than in another.

BUT if the arteries in any particular part of the body be so constructed as to admit of a quicker, and greater degree of dilatation than the rest, in proportion to their elastic power, the blood must be collected in these vessels, and must produce a PLETHORA in them, though there be none in any other part of the body, the rest of the arteries propelling the blood with their usual energy.

IF we compare the aorta, and iliac arteries with those of the UTERUS, which admit of a sudden, and great dilatation, it will appear that the blood, being impelled by the strong vibrations of the former arteries into the latter, must be collected there; for the uterine arteries, not being possessed of an equal degree of elastic power, according to their capacities, cannot propel the blood so quickly

quickly as it is conveyed to them. By this mechanism, joined with the disposition to imbibe blood from the neighbouring arteries, with which the UTERUS is supposed to be endued at particular times, there must be such a derivation of blood to these parts, as, with the change in its quality, shall at length be sufficient to overcome the resistance of the vessels.

THAT a partial PLETHORA may take its rise from a natural cause, and may subsist without a general PLETHORA, appears sufficiently from the state of the UTERUS after impregnation; the blood vessels, during that period, particularly in the last months, being distended greatly beyond their usual dimensions *. Nor do pregnant women, if

* Quamvis autem uterus in junioribus puellis, et in adultis virginibus, ad tactum firmus et solidus deprehendatur; tamen graviditas docet hæc vasa facile cedere posse, et in magnam amplitudinem dilatari, cum ultimo graviditatis tempore, uterus instar spongiæ sanguine planæ appareat, cum vasa ante vix conspicua in utero non gravido, jam digiti minoris apicem quandoque capiant. Van Swieten.

if in health, discover any symptoms of a general PLETHORA, though the womb be then in a plethoric state: on the contrary, many women, who enjoy perfect health during that period, look leaner, and less plethoric than before impregnation.

IT is to be observed, that, in investigations of this kind, we ought not to take observations from women who are in any degree pained about the time of menstruation. There are many women, particularly of the middle rank of life, who live in the country, and who, from the benefit of fresh air, sufficient exercise, simple diet, and tranquillity of mind, feel no inconvenience, nor have any symptoms of a general PLETHORA about the time of the menses.

BUT, though we daily meet with others who have evident symptoms of a general fulness, and a variety of troublesome feelings about that period, we ought not therefore to conclude that these symptoms are
more

more necessary than the many inconveniences which are frequently found to attend the other evacuations. It is from those only who enjoy perfect health that we can judge with propriety of the œconomy of nature in animal bodies.

It may be objected that the uterine vessels, when they suffer so great an expansion from the impulse of the menstrual blood, must, by their reaction, produce a general PLETHORA in some degree.

SOMETHING of this nature might be supposed to happen did the conveyance of blood into the uterine vessels depend solely on the action of the neighbouring arteries: but the UTERUS, according to this theory, being, by its particular constitution, and at certain periods, disposed to imbibe blood, the impelling force of the neighbouring arteries becomes less necessary, nor can any degree of a general PLETHORA arise from the
reaction

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reaction of the uterine vessels, when thus disposed to attract the menstrual blood.

It doth not appear that any satisfactory account of the conveyance of the menstrual blood to these parts can be given, without having recourse to an absorbing quality in the uterine vessels. For, if the determination of blood to the UTERUS depended wholly upon the action of the neighbouring arteries, then ought the menstrual flux to increase, or diminish, as the action of these arteries, and the momentum of the blood become greater or less; which doth not agree with common observation: for neither the times, nor quantities of the menses are affected by exercise and rest, or by the stronger, or weaker action of the heart, so much as they ought, if the periodical collection of blood in these parts depended wholly on its momentum being increased by the addition of a few ounces.

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THERE

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THERE seems to be some analogy between the seeds of plants and the UTERUS of animals. Seeds have a remarkable attracting, and absorbing quality, so that, when they are exposed to warmth and moisture, more or less, according to the nature of the seeds, they soon imbibe, swell, and germinate: and, though the external pressure of the ambient moisture may have its effect in forwarding this change in the seed, yet doth its internal motion arise chiefly from its attracting, or absorbing virtue, depending upon its original organization. The efficient cause of this is unknown to us. On this natural disposition of the seed the nourishment and growth of the future plant, in a great measure, depends; and seeds which have reached maturity imbibe more readily, and more plentifully, than others which have never come to a full ripeness: accordingly, the latter produce either weakly plants, or none at all.

IN like manner may the UTERUS, at a particular period of life, or when come to a certain degree of maturity, acquire a power of absorbing the menstrual blood, allowing still the adjacent arteries to have their share in forwarding this accumulation of blood; for which, however, the action of these arteries seems to be of itself insufficient, without the absorbing power of the uterine vessels.

BUT, though a partial or local PLETHORA be here allowed, it can only be understood to be so on certain conditions. A PLETHORA is commonly supposed to include something morbid. But, in the present case, it can have no meaning of this kind, since the uterine vessels, in collecting, and voiding the menstrual blood, discharge their natural functions, as much as the liver in secreting bile, or the urinary bladder in collecting, and discharging the urine.

BUT, if by a partial PLETHORA be meant such a quantity of blood collected in

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any particular organ, as cannot be propelled in the common course of circulation, whether this proceed from the peculiar dilatability of the vessels, and their small elastic power in proportion to their size, or from whatever other cause, then must the UTERUS be allowed to be in a plethoric state about the time of menstruation.

By a general PLETHORA, as hath been observed above, is understood a greater quantity of blood than the moving power is able conveniently to circulate: but the blood cannot thus exceed the mean quantity without a morbid state of the body. Now it would be preposterous to suppose a natural effect, or such as is indispensable in the animal œconomy, to depend necessarily upon a morbid, or unnatural cause*.

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* It may be proper to observe, that, by a natural cause, or effect, nothing more is meant here than what is necessary or conducive to the preservation of the animal œconomy, without regard to the general or abstract sense of cause and effect. Thus, poison, taken into the stomach, may destroy the animal frame by reducing the blood to a putrid state. This, with respect to the
animal

THIS is a difficulty in which those must be involved who suppose a general PLETHORA necessary to produce the menses. And with respect to a partial, or local PLETHORA, that name may be assigned to it, or not, according to the sense affixed to the word.

IT hath been said that the erect posture of women is one cause, among others, of menstruation: and that the horizontal posture of brutes contributes to prevent it in them.

BUT, though the internal parts of generation in women be perpendicular, or nearly so, the vessels belonging to these parts are
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animal oeconomy, is an unnatural, or morbid effect, produced by a cause of the same kind. But the resolution of the blood is a natural effect of the poison, when considered in an abstract sense, and without regard to the animal oeconomy. This observation is the more necessary, that the words *nature*, and *natural*, being variously applied, have sometimes been misunderstood. Natural actions are mentioned sometimes as contradistinguished from vital, and animal actions; at other times in opposition to unnatural actions.

mostly horizontal, or obliquely lateral; which direction is the most commodious for collecting the blood, and for preventing its too sudden eruptions. And, though the perpendicular column of blood betwixt the heart and the UTERUS may have some effect in promoting the menses, this can be but inconsiderable, when compared with the impelling force of the aorta, iliacs, and hypogastric arteries, and with the aptness of the uterine arteries to absorb the menstrual blood at these periods; hence it is common for women, confined to beds, to menstruate as regularly as others in health, who use an erect posture.

THE diseases incident to the UTERUS are known to be numerous, nor is any other part of the body so immediately affected by the passions of the mind. ‘*Uterus nullum sibi præter animi pathemata hostem novit,*’ says Van Helmont; and it is remarkable that the same passions are frequently productive of opposite effects. A violent emotion of
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the mind, from grief, or anxiety, from a sudden fright, or from an immoderate fit of anger, sometimes stops the menses; and, at other times, proves the cause of an immoderate flux. . It must be owned, however, that the mutual influences of the mind and body upon each other is so intimately connected that it is frequently difficult, if not impossible, to distinguish which is the cause, and which the effect. But it is certain that extravagant emotions of the mind are often the immediate cause of irregularities in menstruation.

WOMEN, who live in indolence, and delicacy, having for the most part weak systems of nerves, the common effect of too little exercise, the mind thereby contracts an imbecillity, which discovers itself by a too great quickness, and sensibility of the passions; a state of the mind rarely to be found among women who lead active lives, or who are much accustomed to labour. From too great an irritability of the nerves, from a defective perspiration,

perspiration, and other effects of indolence, follow irregularities in the digestions, secretions, and, in general, in the circulation. Accordingly, women who are naturally indolent, or whose business restricts them to sedentary lives, are observed to be subject to palpitations of the heart, soundings in the ears, indistinct vision at times, giddiness, tension about the hypochondria, yawnings, sighings, quick breathing upon using motion, lassitude, coldness sometimes in one part of the body, and sometimes in another, as in the scalp, nap of the neck, or spine of the back, and particularly in the feet and legs. Besides these symptoms, flatulency and costiveness are evils attending this kind of life. These symptoms, when met with in female constitutions, are commonly ranked among hysterical disorders, though they do not always proceed immediately from any fault in the UTERUS; they are, however, for the most part attended with irregular menstruation.

WHATEVER

WHATEVER regimen invigorates the body, and contributes to animation, will be found to correct, or remove these disorders, and to forward the operation of medicines. Hence the success of attending mineral wells. For, though the waters may have their share in rectifying enfeebled constitutions, there are many other circumstances which prove no less salutary. On these occasions, exercise, rarely neglected at the wells, new and agreeable company, change of air, a variety of scenes, in travelling to and from the Spaws, regularity in diet, and proper food, commonly attended to during the use of the waters; and absence from business, or from whatever may be productive of care and anxiety in the mind; these circumstances, I say, by amusing and supporting the mind, and invigorating the body, cooperate to repair the constitution. Thus, as immoderate menstruation, and likewise obstructions, are frequently effects of the same cause; so are these effects, however

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opposite,

opposite, often corrected by the same method.

IN obstructions of a more obstinate nature, the UTERUS seems entirely to lose the faculty of absorbing blood from the adjacent arteries, so that, in these cases, the symptoms which used to precede the monthly flux are not at all felt. But though the uterine vessels may, in some degree, retain or recover this absorbing quality, it frequently happens that they are unable to discharge the menstrual blood. This is known to be the state of the UTERUS, when, at the expected period, but without any subsequent menstrual discharge, there is a sensation of the ordinary symptoms which used to indicate the approach of the periodical flux. In this case it is to be presumed that medicines of a warm and stimulating quality may be given with greater advantage, and safety, than in the former, in which the uterine vessels, being in a collapsed state, cannot be supposed to be affected by the virtues of medicines,

dicines, with the same advantage, as when these vessels admit a proportion of the menstrual blood. I had lately an opportunity of knowing the case of two women under uterine obstructions, who, for several months, not having felt any symptoms indicating a derivation of blood to the UTERUS, were, by the use of an empiric medicine, given as a certain deobstruent, thrown into considerable disorders, as throbbings about the *præcordia*, a quick low pulse, faintishness, and the like symptoms: others, with whom the menses flowed very sparingly, used the same medicine with advantage.

WHEN the menstrual blood is received into the uterine vessels, and is not discharged, but retained there some time, being again taken up in the course of circulation, and mixing with the other fluids of the body, it creates numberless disorders in the constitution.

FOR the disorders of the UTERUS there is hitherto no medicine known, which can be properly termed a specific, or whose effects are equally certain in these disorders, as the bark in intermitting fevers, or as mercury in exciting a salivation.

ALOES having been found effectual, in opening the hemorrhoidal vessels, hath therefore been used as an emmenagogue. But it may be doubted whether it doth not, by this effect, divert the uterine flux, since, by increasing one discharge, we generally find others to be diminished. Nor is it improbable that the communication betwixt the uterine and hemorrhoidal vessels may have been intended to relieve the UTERUS upon occasions. When women reach that period of life, in which the menses begin to cease, they are often subject to a discharge of blood by stool, the hemorrhoidal vessels, in so far, carrying on that flux, when the UTERUS becomes unfit for it; and there is reason to believe that, in the early periods of pregnancy,

nancy, miscarriages have sometimes been prevented by an hemorrhoidal flux, when not immoderate, the uterine vessels being thus relieved, when a less proportion of blood was sufficient for the nutrition of the embryo than was perhaps conveyed to the UTERUS and neighbouring parts. But, as purgatives are frequently necessary in uterine obstructions, aloes may be preferable to many other cathartics, being of a warm and stimulating nature; and, as such, hath been used ever since the days of Celsus *.

MERCURY, from its weight and divisibility, proves, in many cases, a powerful deobstruent, and gives an *impetus* to the mass of blood. But, from the soft and loose texture of female bodies, it hath been found either to run off by stool, or to affect the glands of the mouth, before it overcome the uterine obstructions. Opium, steel, castor, colocynth, and many other medicines are

* Sed medicamenta stomachum fere lædunt, ideoque omnibus catharticis aloë miscenda est. Lib. 2. cap. 12.

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are known to have virtues in hysterical disorders, when properly applied.

IT hath been proposed, by some, as a problem, why phlebotomy doth not answer the purposes of a discharge of blood by the UTERUS.

HAD the cause of the menses been a general PLETHORA, an equal quantity of blood taken from any other part of the body might have prevented the uterine flux; but, in this event, nature would have been defective with respect to the final cause; since every accidental hemorrhage, though from parts of the body remote from the UTERUS, would have endangered, if not destroyed the foetus. There are many instances which tend to prove that phlebotomy hath little, if any influence, either in promoting, or in stopping the menstrual flux.

WHEN we consider that the blood is conveyed to the UTERUS by large and elastic arteries,

arteries, and to this when we add the particular disposition, or absorbing quality, with which the uterine vessels are supposed to be endued, it will appear that this organ must be supplied with blood, so long as the heart acts, and the UTERUS retains that faculty. Accordingly, many women menstruate regularly, notwithstanding profuse hemorrhages from other parts of the body; and it hath often been found that tedious and wasting diseases do not prevent the monthly flux.

AN antipathy to phlebotomy, or a natural timidity, may, with some women, affect the menstrual flux. But this effect must be ascribed to a passion of the mind, which, as hath been already observed, hath no small influence on the UTERUS. Phlebotomy hath been often found necessary and successful in correcting other disorders, not only during menstruation, but during the flux of the *lochia* *.

FURTHER,

* Van Swieten. comm. in aphor. Boerh. de pleurit. Tulp. observ. med. lib 2. cap. 2. La Motte traite des accouchem. liv. 2. cap. 21.

FURTHER, by observing final causes, which merit our attention, while we investigate the operations of nature, there is reason to believe, from the œconomy of female bodies, that the preservation and nutrition of the fœtus, from its first rudiments to its birth, are of so great importance as to render it necessary that the UTERUS should be endued with a temperament peculiar to itself, so as to act, in some respects, independent of the other parts of the body: and that, though a plentiful source of blood be in constant readiness in the neighbouring vessels, yet that the action of these arteries is insufficient to impel the menstrual blood into the UTERUS, till it be prompted to admit that blood by a stimulus, or faculty within itself, and independent of any external *impetus*. So that all these neighbouring arteries are subservient to the UTERUS, to supply it with blood; though insufficient, by their own action, to extend its vessels beyond their invisible state, till they be disposed, by their natural and peculiar faculty,

faculty, to absorb the menstrual blood, or so much as shall be sufficient for the nutrition and increment of the foetus*.

It may be further observed in support of this theory of an innate power of attracting blood, that the UTERUS is most plentifully supplied with blood, when the arteries are in a direction the least favourable for conveying it: for in the last period of gestation, when the UTERUS is so raised as to bear up the abdominal *viscera*, many of these arteries, instead of their former depending situation, are now bent upwards; and yet their ramifications, spread over the UTERUS, are never more turgid with blood, than when they are in this direction. But the weight of the foetus and secundines at birth, compared with that of the menstrual flux of nine months, is likewise a proof of the extraordinary

* Van Helmont had an idea of the *uterus*, as endued with a faculty, or power of this kind, independent, in so far, of the other parts of the body. 'Cum sit uterus, perigrini hospitis instar, a corpore non nisi alimentaliter dependens, prout viscus ab arbore cui innascitur. Cæterum uterus quadra vivit propria,' &c.

traordinary quantity of blood conveyed to these parts during gestation.

AFTER impregnation the foetus seems to be supplied with nourishment preferable to any part of the mother's body. Women, labouring under wasting diseases, particularly pulmonary consumptions, are frequently delivered of children, whose full and healthy appearance bears no proportion to the emaciated state of the mothers. This shews the circulation in the body of the foetus to have been more natural, and regular, than that in the mother's, with whom the action of the heart is, sometimes in these cases, so weak, that the circulation is, with difficulty, kept up *. When we compare this with
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* This more natural circulation in the body of the foetus, than in that of the mother, may be accounted for, in some measure, from the moving power in the child's body being greater than that of the mother's, in proportion to the size of the two bodies, according to the universal law, which obtains in mechanics: for, of similar machines, the smaller do more, in proportion to their magnitudes, than the larger. In the present case, the foetus can have no nourishment but the tainted blood of the mother; and
yet

what hath been observed, with respect to menstruation during these diseases, we may judge of the absorbing power of the uterine vessels.

M 2 E S S A Y III.

yet we frequently see children reach a certain age and size before these diseases discover themselves, though the children must have had the morbid *fomes* in their original *stamina*. Something of the same nature may be observed in vegetables, and probably from a similar cause. Many plants decay, after having come to a certain size, with an healthy appearance; and the blights and mildews in corns are believed to be owing to a vitiation in the seed, which is said to be corrected by soaking the seed in nitrous and other *lixivia*. But, with respect to the foetus, perhaps the blood, which is conveyed to it, may undergo such a percolation, in passing from the uterine vessels to those of the *placenta*, as to render it purer than that circulating in the mother's body; and thus it may contribute to the more salutary state of the child.

ESSAY III.

OF

MEASURING PROPORTIONAL
QUANTITIES OF HEAT.

ESSAY III.

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MEASURING PROPORTIONAL QUANTITIES OF HEAT.

IT is about a century and an half since philosophers began to measure the degrees of heat by means of instruments constructed for that purpose, nor is it certain to whom we owe this discovery. Galileo, Sanctorius, Father Paul, and Drebbel have their respective advocates *. It is not improbable that these instruments might have been

* The Dutch authors; particularly M. Hennert, one of the latest writers on this subject, make Drebbel the inventor. L'honneur de cette Découverte, says M. Hennert, appartient aux Hollandois.—Je ferai voir que Sanctorius n'est pas l'inventeur des thermometres. Drebbel is said to have invented his thermometer at Prague, during the siege of that town by the king of Bohemia, or afterwards in England. The siege of Prague was in the year 1620. It is probable, from Sanctorius's aphorisms, that he had used a thermometer during his experiments. The aphorisms were

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been contrived by different inventors about the same time, since that was a period in which experimental philosophy began to be a serious study.

THE illustrious Sir Isaac Newton, observing lintseed oil to admit of considerable degrees of expansion by heat, constructed a thermometer with that liquor: and, supposing the freezing point to be the limit betwixt heat and cold, graduated the thermometer upwards, making 12 degrees the heat of the human body: so that the heat of boiling water was something more than 34 of these degrees *.

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were first published at Venice in 1614; that is, six years sooner than M. Hennert says that Drebbel had invented his thermometer. It may be further observed, since Drebbel's and Sanctorius's thermometers were of the same construction, that Drebbel might have had the idea of his from that of Sanctorius.

* To make Sir Isaac Newton's thermometer coincide with Fahrenheit's, boiling water ought not to be quite so high as 34.— $34 - \frac{2}{3} = 33\frac{2}{3}$, which is the degree of boiling water in Sir Isaac's scale, that of animal heat being 12. But Sir Isaac found that from the first boiling to the most violent ebullition, the thermometer moved from 33 to 34.5 degrees in his scale, which, in Fahrenheit's, is no less than 8 degrees.

SIR ISAAC, supposing equal dilatations of the fluid to indicate equal quantities of heat, makes the heat of boiling water to be nearly equal to thrice the heat of the human body.

WERE it certain that the freezing point is the lowest boundary of heat, and likewise that equal quantities of heat produce equal degrees of rarification in the fluids, then would the mensuration of heat become an easy matter.

BUT it hath not yet been determined whether there be really such a thing as frigorific particles essentially distinct from heat. What we denominate cold, for all that hath been said on that subject, may still be no more than a diminution, or defect of heat, to certain degrees, according to the feelings of different animals, or of the same animals at different times, and the various sensations of heat and cold may depend upon the particular organization of animal bodies; so

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that

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that a medium, yielding a sensation of warmth to animals living in the polar circles, might quickly chill us to death.

WERE we to suppose the first degree of heat to be six divisions of Sir Isaac's scale lower than he hath made it, which is the beginning of Farenheit's, then would the proportion of the heat of the human body be to that of boiling water, only as 3 to 7 nearly: and were the first point to be moved still lower, which, for what we know, ought to be the case, the proportions would vary accordingly.

As we are ignorant, therefore, of the beginning of heat, and probably shall never be able to discover the boundary betwixt heat and cold, or whether there be such a thing in nature as an absolute privation of heat, it is in vain to attempt the mensuration of any certain quantity of absolute heat.

BUT

BUT as we may have *data* sufficient to discover the proportion which different quantities bear to one another, without being able to measure any one of these quantities; so may we be able to measure the proportional degrees of heat, though it be not in our power to measure any quantity of absolute heat. Thus we may suppose ourselves able to discover the proportional distances of two, or more planets, from the sun, without being able to measure the real distance of any of them.

THE great difficulty in this attempt is to discover the *ratio* betwixt the dilatations of the fluids and the proportional quantities of heat upon which these dilatations depend. For though it be probable that the rarifications of different fluids bear different proportions to equal quantities of heat; yet is it uncertain whether there be any fluid which admits of additional rarifications precisely equal to additional quantities of heat.

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THE heat of the human body in a morbid state is found sometimes to exceed its natural heat by 10 or 12 degrees * ; that is, from 95 or 96, to about 10 or 12 degrees upwards. But we do not know whether the same additional quantity of heat applied to the thermometer, when the mercury stands very low, might not raise it twice or thrice as many degrees.

It hath been demonstrated that the density of all rays, issuing from one common center, is in the inverse *ratio* of the squares of the distances from that center † : and, as heat is propagated in right lines, as is universally believed, its strength, or intensity will be in the same *ratio*.

FROM this well known proposition, a method is pointed out for constructing thermometers

* Mr Burton, on his thermometers, makes the natural heat of the blood 97 degrees, and fever-heat 112. ; which latter is higher than I have ever found it,

† Keil's physics, lecture 1.

mometers shewing proportional quantities of heat; an instrument greatly wanted among naturalists.

IF a thermometer, to be graduated in this manner, be placed at a given distance from any equal central heat, suppose at six inches; when it will rise no higher, if it be removed to the distance of twelve inches, the heat in the former station will be to that in the latter as 4 to 1. If the thermometer be removed to a third equal distance, the heat at the first station will be to that at the last as 9 to 1. That at the second to that at the third as 9 to 4; and so on. The numbers I, II, III, IV, &c. *, being marked on the scale, to shew the height of the mercury, corresponding to the different distances of the artificial heat, marked 1, 2, 3, 4, &c. the intermediate spaces may be divided indefinitely into fractional parts.

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* Plate II. fig. 1.

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THE instrument being graduated, if experiments are to be made, or the heat of two or more bodies to be compared, if the body or medium A, raise the mercury to a height corresponding to the distance 1.53, and the body B, to that corresponding to the distance 2.63. then would the heat of the body A, be to the heat of B, as $\frac{2.63^2}{1.53^2}$.

SOME have been of opinion that the force of heat is not propagated according to this law; because heat in the focus of a speculum, especially those of the larger kinds, is very intense; whereas, at a moderate distance from the focus, we feel little or no heat.

BUT the reason of this is evident; for the rays diverging very quickly, soon become as rare as before they were collected. Thus the rays reflected from the speculum A B *, having passed the focus F, become as rare as the parallel rays which fell on the speculum, when these diverging rays are at the same distance from the focus as the fo-

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* Plate II. fig. 2.

cus itself is from the speculum. So that the distance betwixt the focus and D, C, or E, is too little for experiments of this kind.

It may be further observed, that, though the rays issuing from a center would affect a thermometer according to this law, yet, if we were to apply the thermometer to the ignited body, or to immerse it in the flame from which the rays are emitted, this law would cease, the heat of the ignited body being much beyond the highest proportion of heat in the rays. But the focus of a speculum is to be considered, with respect to the intenseness of heat, as an ignited body, from the great collision of the particles of heat at the decussation of the rays; so that the heat of the rays, at a very small distance from the focus, are found to bear no proportion to the heat in the focus.

ONE difficulty, which attends this construction of thermometers, is to find an equal central heat: for, if the heat were to
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vary but in a small degree, the proportions would be lost. Did concave mirrors form pencils of rays of a sufficient length for experiments of this kind, they would perhaps be less exceptionable than any other method: but they are open to the objections just mentioned. Ignited metals cool according to a certain *ratio*; but to make allowance for this *ratio*, if it be really known, or to take it into the computation, would render the operation difficult, if at all practicable. The flames of candles seem to yield the most invariable heat, provided it were strong enough to procure a scale of any considerable extent. But, till a better method shall be discovered, candles may be used with advantage in the following manner.

In place of making experiments of this kind by heat emitted from any central body, several candles may be placed at equal distances from the thermometer, and the proportional degrees of heat discovered by
moving

moving the candles towards the instrument. For this purpose let a frame be constructed in the following manner.

Two beams, or pieces of wood, A B, and C D *, each two inches thick, four inches broad, and four feet four inches long, are to be fixed or sunk into one another at the middle, E, so as to form four equal branches, making so many right angles with one another at the middle. In each branch must be a slit wide enough to receive a square wooden socket, *e*, in which must be a cylindrical hole sufficient to receive a large candle. The slit in each branch must be so long that the centers of the sliding sockets may be moved from the distance of 24 inches to that of 2 inches from the central point E. On each branch are to be marked cross lines, or divisions, at the distance of two inches from each other, as in the figure, and that next the center being two inches from it, the division next the extremity of each

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branch

* Plate III.

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branch will be 24 inches from the same central point. Each of the sliding sockets must likewise be marked with a line parallel to those on the branches, and passing through the center of the cylindrical hole; so that, as the sliding sockets are moved along the flits, this line, falling in with the lines on each side, will shew exactly the distance of the axis of each candle from the center of the frame.

IT will be further proper that the divisions on the branches be subdivided into tenths, twentieths, or as many fractional parts as may be convenient; that, in moving the candles towards the thermometer, allowance may be made for the thickness of the ball. Thus, if the diameter of the ball be six tenths of an inch, then, in place of moving the sliding socket so far forward as to make its cross line coincide with that of the great division, it must be three tenths of an inch short of that division.

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THE frame ought to be supported by four feet, one at the extremity of each branch ; and, that the reflexion of heat from the table or floor, on which the frame stands, may not affect the mercury, these feet ought to be four inches high at least.

THE frame being thus prepared, the four candles, fixed in the sockets, are to be placed at the divisions next to the extremities of the branches, and a thermometer to be hung, precisely over the central point of the frame, so high that its ball may be in an horizontal plane with the flames of the candles. Having observed the precise height at which the mercury stands by the heat of the candles at the most distant station, let the sockets and candles be moved to the next station, and so on through the twelve stations. But in this process there are several precautions which ought to be carefully attended to.

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1. THE tube, or stem of the thermometer to be graduated, must be fitted to a plate having Farenheit's divisions on one side* ; the other side to be left open for the new scale: the ball of the thermometer must be open on all sides, that the heat from the four candles may act upon it without interruption.

2. THE observer must not touch the thermometer during the operation, lest he give it a vibratory motion, and must hold an handkerchief over his mouth, while he observes the height of the mercury, that his breath may not communicate any additional heat to the air about the instrument; nor ought more than two persons to be in the room during the operation.

3. THE interval betwixt each observation must be of a sufficient length, that the observer may be sure that the mercury will
rise

* Plate II. fig. 1.

rise no higher before he move the candles to the next station.

4. THE thermometer must be so hung that it may be let lower as the flames of the candles become lower: for the ball of the thermometer must be constantly in an horizontal plane with the flames of the candles.

5. THE candles must be exactly cylindrical from top to bottom; they ought likewise to be thicker than ordinary candles, that their flames may yield the greater heat; and they must stand precisely perpendicular, for which purpose the sockets must be pretty deep. They ought to be made of the finest tallow; for though waxen candles yield a purer flame, their heat is not so great. They must be regularly snuffed during the operation.

6. THIS operation ought to be in a large room, and the *apparatus* must be in a
part

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part of the room where there is no current or circulation of air.

7. THERE ought to be one or more thermometers in the room, at some distance from the *apparatus*, to shew that the air of the room without the sphere of the candles retains the same degree of heat from the beginning to the end of the process; and when this is the case, then will the rising of the thermometer be the effect of the heat of the candles only, and the various heights of the mercury will be in the proportion mentioned above.

FROM some experiments made to this purpose, it appears that four candles of an ordinary size make a sensible impression on the mercury at the distance of two feet; and that the same candles, when brought to the distance of three inches from the ball of the thermometer, raise the mercury to 86° . in Fahrenheit's scale, when the thermometer, by the heat of the air, stands about 40° . so that, by
larger

Quantities of Heat. III

larger candles, and these brought so near as two inches, it is to be believed that the mercury may be raised considerably above 100° . and if the state of the air be such that the thermometer stands about the freezing point, a scale of the extent of 70, 80, or perhaps 90° . of Farenheit's thermometer may be procured ; and, consequently, we may, by this method, be enabled to compare proportional degrees of heat, from the freezing point to the heat of the human body, and upwards.

BUT, if more heat be wanted, a frame may be constructed to receive six, or eight candles. It may be further observed, that the ascent of the mercury, upon moving the candles from the most distant station to the next, may be so small, that it will be adviseable to advance the candles four inches in place of two, for the two or three first observations, that is, from 24 to 20, and from 20 to 16, &c. inches from the ball of the thermometer.

IT

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It is not meant that thermometers, graduated after this manner, should supersede Farenheit's, and other thermometers now in use: these would still be valuable, as well for their easy construction, as for the great extent of their scales, and would serve all the common purposes of regulating heat. Nor is it pretended that this proposal is, in every respect, secure against objection, or that the execution will be unattended with difficulties. It is, however, worthy of being brought to trial, being an attempt to find the solution of a problem which hath been given up as impossible: and if the construction of thermometers after this manner be found to answer as well in practice as in theory, we should be satisfied in many parts of natural history hitherto unknown, such as the proportion betwixt the mean heat of summer and that of winter, betwixt the heat of the human body and that of the air at different seasons, and many other curious problems which cannot otherwise be solved.

It may, at first sight, appear an objection, that the scales will be different according to the different degrees of the heat of the air when observations of this kind are taken. Thus, in winter, or when the air is very cold, a longer scale would be procured, than in summer, when the mercury stands high, though we use the same artificial heat, and at the same distances.

THIS is indeed true. But the difficulty vanisheth, when we consider, that, though the one scale be more or less extensive than the other, their divisions will, nevertheless, be proportional. Thus, if the heat of the air be at one time as twenty, and at another as thirty; and the additional artificial heat, or its excess above the heat of the air, as five in one station, and as ten in another, these two numbers, bearing an higher proportion to twenty than to thirty, will affect the thermometer more in the former state of the air, than in the latter; and, consequently, will make a larger scale, when the

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air

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air is cold, than when it is hot, though their divisions will be proportional to one another, as the lines BC , DE , FG *, in the triangle ABC , and the parts of these lines, divided by An , and Am , are all proportional to one another.

AGAIN, if BC be one scale, and FG another, then will the heat at m , bear the same proportion to that at n , as the heat at o , to that at p . If C be the height of the mercury in a cold state of the air, and when the artificial heat is at the most distant station, and G its height, when the artificial heat is at the same distance, but the air in a warmer state; then will the difference be Cr : but, when the artificial heat is brought so near as to raise the mercury in the one scale to p , and in the other to n ; then will the difference be ns . In general, the less the difference is betwixt the artificial heat and that of the air, the scale and its proportional parts will be the smaller, as HI ; and
if

* Plate II. fig. 3.

if the heat of the air be supposed equal to the artificial heat, that is, the line AC , to meet the line AB , as at A ; then, the difference being destroyed, no scale could be obtained; for to mix two fluids of an equal degree of heat, makes no increase of heat.

Thus, by taking different scales, when the air, with respect to heat and cold, is in the most opposite states, we may be enabled to form a general scale, shewing the proportional degrees of heat, in any state of the air. For example, when its heat is about twenty-five degrees, the scale bd^* may be procured; and the scale ac , when its heat is about 77. These two scales being delineated, or engraved parallel to, and at any proper distance from one another, as ac and bd ; and lines being drawn from the numbers of the one scale to the corresponding

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* Plate IV.—It may be observed that the example of this general scale of proportional heats, in the plate, is not digested from experiments, or according to proportions founded in nature; but only to shew the form and use of such a table,

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ing numbers of the other, as from I to I, from II to II, from III to III, and so on, a table may be formed which will shew the proportional degrees of heat in any state of the air betwixt these two scales.

Thus the lines *ab*, and *cd*, with the intermediate oblique lines, shew the form of such a general scale: and, having discovered the *ratio* of the distances betwixt these lines, they may be produced to any length; for, as nature constantly acts by some law, it is to be presumed that this law may be ascertained by a sufficient number of experiments.

THIS table ought to have Farenheit's scale on each side, as AC, and BD, with parallel horizontal lines passing from the numbers of one side to the same numbers of the other, at proper distances, as from 120 to 120, from 100 to 100, from 80 to 80, &c. Thus the height of the mercury in Farenheit's thermometer may be conveniently compared with the table of proportional

tional heats, the parallel lines of the one intersecting the oblique lines of the other.

THE use of this table will appear better from an example. If the heat of the human body is to be compared with that of any other body, or medium of seventy degrees in Farenheit's thermometer, the heat of the air being in some intermediate state betwixt the two scales of proportional heats, as *ef*; then *m*, being at ninety six in Farenheit's scale, is the heat of the human body; and *n*, being at seventy in the same scale, is the heat of the other body. Therefore, *m*, falling on the scale *ef*, at IV, and four tenths *, that is, at the number shewing the distance of the artificial heat from the thermometer, and *n*, falling on the same scale at the distance of VIII, and six tenths, the heat at *m*, will be to that at *n*, as $\overline{8.6}^2$ to $\overline{4.4}^2$: that is, the heat of the human body will be

* It is sufficient, in this example, to suppose the fractional parts, though none be marked on the scale.

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be to that of the other body as 73.96.
to 19.36.

IN this manner may the heat of two or more bodies be compared. But, if the heats of the same two bodies are to be compared with the heat of the air when in different states, it will be necessary to find the proportional numbers, shewing the heats of these bodies in the different scales, before comparing them with that of the air.

IF, therefore, the heats of the same two bodies are to be compared when the air is in a cooler state, as in the scale gh , then the numbers, expressing the proportional heats, will be different, but in the same *ratio* as the preceding numbers; for the heats ninety six and seventy, in Fahrenheit's scale, falling now at o , and p , will be in the following proportion; $n : m :: p : \frac{mp}{n} = o$; which is in numbers thus, $73.96 : 19.36 :: 39.69 : 10.39$. which last 10.39, is the proportional heat

at

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at p , the square root of that number being the distance of the artificial heat from the thermometer, corresponding to o , in this scale; and bears the same proportion to 39.69, the heat at o , as 19.36, to 73.96.

IN comparing the heat of any body with that of the air, it may be observed that, of the two numbers shewing the proportional heats, the one will vary as the scale is larger or smaller, the other will be constantly as the square of the greatest distance of the artificial heat from the thermometer, which will be nearly the natural heat of the air at the time of the experiment. Thus, when we compare the heat of the blood with that of the air, when the thermometer stands at sixty degrees, as in the scale ef , the heat at m , will be to the heat at f , as 144 to 19.36. But in the scale gh , that is, when the thermometer stands at forty degrees, the heat of the blood will be to that of the air as 144 to 10.39. In the same manner, the
heat

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heat of the other body, or medium of seventy degrees, may be compared with that of the air.

ESSAY IV.

ESSAY IV.

O F

INSALUTARY CONSTITUTIONS of the AIR, from a Defect of WINDS of the higher Degrees.

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OF

INVESTIGATION BY COMMISSIONERS
TOWNSHIP OF THE AIR, LAND &
DEEDS OF WINES OF THE
HIGHER TO GROW

ESSAY IV.

O F

INSALUTARY CONSTITUTIONS of
the AIR, from a Defect of WINDS
of the higher Degrees.

IN the registers of the weather, which have been kept with a view to ascertain the remote causes of epidemical diseases, the gravity, heat, and humidity of the air, have been regularly attended to; the quantities of rain, and the direction of winds, have likewise sometimes been noted; but the degrees of winds have frequently been neglected. It is intended, in this short essay, to shew the impropriety of this omission, in these registers.

As the cause of winds hath been frequently a subject of enquiry among natu-

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ralists

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ralists in general, so have their effects upon animal bodies more particularly attracted the attention of medical authors ever since the days of Hyppocrates.

WHEN we endeavour to trace the causes of epidemical diseases from journals of the weather, if in these journals the degrees of winds have been omitted, we are not only unable to draw any satisfactory conjecture from them, but are frequently led to believe, either that the state of the air, or that of diseases, ought to have been opposite to that which appears from the registers.

THUS, when we find, in a journal of the weather, that the barometer hath been very low for a considerable time, the humidity and heat being at a mean degree, we are apt to conclude this constitution of the air to have been unwholesome; which is often the case, when a low barometer is attended with continued calms. But when this low state of the mercury proceeds from high and stormy

stormy winds, it, for the most part, indicates a salutary constitution of the air, and, in so far, the agitation of the air seems to compensate its defect of gravity.

As to the directions of winds, independent of their force, these which move along the same climates, though with opposite directions at different times, have been found to acquire particular qualities, according to the nature of the tracts of land or water over which they pass. But, in latitudes considerably distant from the equator, winds coming from opposite climates are observed to possess different, and, frequently, opposite qualities, besides those which they acquire from causes common to all winds. This is the case with north and south winds in the higher latitudes.

THE ancients universally ascribe a baneful quality to south winds; and the learned Hoffman, though living in a much more northern climate than the ancient medical authors,

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authors, agrees with them in the effects of south winds. It must be owned, however, that south winds are not so much to be feared in these northern latitudes, nor have north winds always the same salutary effects with us, that Hyppocrates, Aristotle, Celsus, and Galen found them to have in the more southern climates. With us the good or bad effects of north winds seem to depend on the period of the year in which they blow: for, about the end of the spring, or the beginning of summer, when pinching north winds follow a warm state of the air, these winds are productive of rheums, coughs, and inflammations, affecting chiefly the pleura, and lungs. But, from the summer solstice to the autumnal equinox, or some time after it, northerly winds are observed to correct that state of the air which promotes putrefaction, the causes of which in the air are heat, humidity, and continued calms, or warm south winds. The air, when in this state, seems frequently to be impregnated with a sulphureous gas, which,
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at times, manifests itself by meteors, coruscations, thunders, and luminous appearances on swampy grounds.

NORTH winds, in general, check or retard vegetation with us. But, in those parts of Asia and Africa which lie next to the Mediterranean sea, these winds are favourable to vegetation, as we are told by those who have visited these countries*.

HIGH winds are no where more necessary than in great cities, and chiefly after long calms; for the feculencies of different kinds, being collected, contract a more noxious quality than can be corrected by winds of the lower degrees.

By a computation † of the quantities of winds of particular degrees, made from a register

* For the effects of winds depending on their directions, see Lord Bacon's *historia ventorum*, and Hoffman's dissertation *de physici meditationibus circa ventorum causam*, &c.

† By this computation, it was intended to ascertain the proportion of time which may be reckoned upon for the motion of the heavier

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gister of the weather, which had been kept for five years, it appeared that seven months, in two years of that period, were remarkable for a defect of winds of the higher degrees, and bore a small proportion to winds of these degrees in the same months of the other three years.

THE months and years were from June to December, inclusive of the years 1732 and 1735. In which periods the mean proportion of the winds of the third degree and upwards, was to the whole time of these seven months, in each of these two years, as unit to 17.1. But in the same months of each of the other three years, the mean proportion of these winds was to the whole time of the months in each year, as unit to 8.2. This was a remarkable disproportion.

GREAT

heavier kinds of wind machines, such as are used for draining coal-pits by pumps. The register was kept by Doctor Jurin's method, the winds being divided into four degrees. It was necessary for this computation, to find a mean betwixt the second and third degrees.

GREAT storms, as Doctor Huxham observes, frequently give a check to epidemic fevers. In the seven months of the two sickly years, there were only four hurricanes, or winds of the fourth degree. But in the same months of the other three years there were thirty three; that is, the winds of this degree, in each of the former periods, were to those in each of the latter, as 2 to 11.

THAT I might know the effects of this constitution of the air on the human body, I examined the history of diseases during the latter part of these months; and the period following them; for, unless the air be noxious to an uncommon degree, its effects do not appear on the human body till some time after the cause; and the distance of time, it may be presumed, will be greater or less, according as the disposition of the body to admit, or its power to resist the remote morbid cause, are greater.

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To begin with the month of August 1732; the progress of the epidemics was according to the following short account.

FROM the beginning of August to the end of October, a fever of the low kind prevailed, chiefly among the inferior rank of people, and soon became mortal. The fever was attended with severe headachs, ravings, and sometimes with a diarrhœa; in the two latter months, the disease became more fatal, the patients dying about the eighth or ninth day, having been attacked early with a stupor, and lethargic listlessness. Many of the diseased voided worms of different kinds: which, in fevers, generally proceed from bilious or acrimonious humours lodged in the intestines.

FROM the beginning of November to the end of December, aguish complaints, cholera, quincies, rheumatisms, diarrhœas, besides slow fevers, were common.

ABOUT

ABOUT the middle of December, the influenza broke out in Edinburgh, and, in a short time, became so general that very few escaped the disease.

BESIDES the common symptoms, in the beginning of fevers, of a frequent pulse, pain and lightness of the head, aching of the bones, shiverings, and the like, these fevers were attended, or ushered in, with a considerable discharge of *mucus* from the nose and tonsils, and a sharp lymph from the eyes, inflammations of the throat, an incessant cough, and frequently with acute pains in the bowels, followed with looseness and bloody stools *.

BEFORE this fever affected the inhabitants of Edinburgh, the horses had been universally attacked with the disease, manifesting itself by coughs, and a copious discharge of acrid *mucus* from the nostrils.

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* For a further account of this disease, see Edin. Med. Essays, vol. 3. art. 2.

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THIS is justly observed to have been the most universal epidemic on record; having, in the space of three months, appeared in Germany, Britain, Flanders, France, Switzerland, Italy, and Spain *. It attacked Ireland somewhat later. It likewise broke out in the northern parts of America, about the same time as in Europe, travelling southward till it reached the Leeward Islands.

THE effects of this constitution of the air seem not soon to have evanished; for fevers of various kinds continued through most part of the year 1733, particularly the scarlet fever, attended with inflammations in the throat, vomitings and looseness. Small pox were likewise frequent; which, towards the decline of the year, became very mortal.

IN

* I had not an opportunity of knowing the state of the weather in these countries: but the same constitution of the air is known sometimes to prevail over a great part of Europe; this however, passeth unnoticed, unless the attention of the public be attracted by something extraordinary, as extreme colds, long and violent frosts, floods of rain, or the like.

IN examining the epidemics from June 1735, which was the beginning of the other period remarkable for a defect of the higher winds, it appears that measles, gradually increasing, became frequent in the country towards the end of that period. The measles were followed with dangerous and intractable coughs, peripneumonies, and diarrhœas: and numbers who had had the measles formerly were taken with a fever similar to that of the measles.

IN July, a fever of the slow kind prevailed, attended with a low pulse, and diarrhœa, which appeared at one period or other of the disease. Afterwards the cholera and chincough became frequent both in town and country.

IN December, the dysentery began to spread.

FROM the end of the year 1735, till the following February, a low fever was common.

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mon. In this disease, the patients, discovering at first great uneasiness and anxiety, soon became delirious, and were quickly weakened by symptomatic sweats. With others this evacuation proved critical. A third class, with difficulty crept out of the disease without any sensible crisis.

IN the month of February 1736, a fever prevailed in some parts of the country, said to be of the pleuritic kind. But, notwithstanding the pungent pain in the side, this fever seems, from the other symptoms, to have been of that species which proceeds from a resolved state of the blood, and which is frequently produced by that constitution of the air which generates putrefaction.

THIS fever was fatal to many; it was attended with bilious vomitings, and, though the pain about the short ribs seemed to require bleeding, the patients did not well bear that evacuation; their thirst, sickness, and faintness

faintifhnefs being increafed by it. The pulse was neither frequent nor full, and funk immediately on bleeding. The blood was of a brownifh, yellowifh, or greenifh colour, and fcarcely coagulated. The fick were not fenfible of fleeping through the courfe of the difeafe, which was from 25 to 32 days.

THIS is a general account of the difeafes during, and for fome time following, thefe two periods. When we compare the difeafes of the other periods of the five years with thefe, they will appear to have been neither fo univerfal, nor fo dangerous in their kinds. For, excepting a pleurify, in March 1732, the difeafes in the other periods were mild and tractable, and fuch as did not indicate that conftitution of the air which is productive of corruption, and which is fo dangerous to animal bodies.

THAT the remote caufes of the difeafes defcribed above was not owing to any thing remarkable in the gravity, heat, or humidity

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dity of the air, will appear from the following mean state of these three qualities, in each of the five years. For the differences, being inconsiderable, render it it improbable that they could have been productive of such effects.

Mean height of the Barometer, Thermometer and Hygrosc. for five years *.				
Years, each from June to May, inclusive.		Barom.	Therm.	Hygr.
1731.	1732.	29.5.	11.4.	2.
1732.	1733.	29.7.	11.4.	1.9.
1733.	1734.	29.6.	11.7.	1.7.
1734.	1735.	29.5.	11.1.	2.1.
1735.	1736.	29.6.	11.3.	2.1.

THE

* For the mean state in each month, see the Med. Essays.

THE mean quantities of rain, in each of the last seven months for four years, is as follows.

1731. 1.943.

1732. 2.096.

1733. 1.76.

1734. 1.519.

THE register of rain was not kept from June 1735.

WE frequently hear of the plague being transported from one place to another in the cargoes of ships, particularly in bale-goods. That infection hath been conveyed in this way, hath been sufficiently ascertained. But it may be doubted whether such imported infection be very dangerous in the higher latitudes, especially where the air of these climates is purified by high winds, which are frequent in mountainous countries. Even in the southern countries of Europe, the devastation, that is some-

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times

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times made by that disease, seems to depend chiefly upon the constitution of the air at the time when the infection is communicated.

THE great plague at Messina, in 1743, (which was the latest in Europe so far west as that city,) is said to have been brought thither by a Genoese Tartana, and the great mortality in that place was believed to have proceeded wholly from this imported infection. But the rapid propagation of the disease seems to have been more owing to the state of the air for some time before the arrival of that vessel, and to a predisposition in the bodies of the inhabitants to receive the infection, than to any other cause. In the history of that pestilence, it is observed that southern winds, and cloudy weather, had prevailed all that season; and that the inhabitants were thus rendered liable to catarrhs, ulcers and tumours about the glands of the throat and *fauces*, tumours in the parotid and inguinal glands, acrid humours in the

the lungs, and fevers of a bad kind *. From this we may judge how much the body was rendered susceptible of new infection; and it is not improbable that the infection from the Genoese ship would have had but little, or no effect, had the air been purified by cool and dry north winds, instead of the long-continued warm and moist south winds. It may be observed that the account of this state of the air, and of its effects, coincides entirely with those of Hyppocrates, and other authors living in these climates *.

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Now,

* Spesso dominarono torbidi, e nuvolosi venti australi. Avvicinosi indi l'equinozio della primavera dell' infausto anno 1743, e poco men fredda essa mostrossi del trascorso inverno. Continuarono a spirare per lo più gli stessi australi venti, e si patirono non pochi, quasi epidemiali catarrhi, che da qualche tempo in quà si sono resi soliti in ogn' anno. Fu però fatalità imperiscurabile, come vedute si fossero in tal tempo le dette innocenti malattie per alcuni accompagnate d' insoliti accidenti, cioè, oltre della Tosse, Raucedine, dolor de Petto, gonfiamento della Gola, e delle glandole del Collo, ed oltre l' Angine legittime, o spurie ne' pazienti, si videro pur tumefarsi ad alcuni le glandole anguinali, e quelle, che son dietro l' orecchie dette Parotidi, e recavano anco Febri di mal costume. Memoria istorica del Contagio della Città' di Messina, da Orazio Turriano. Cap. 3.

* Quum Auster invaluerit, ejusmodi in morbis contingunt, ulcera madentia, os præsertim, pudendum aliasque partes occupant.

De

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Now, though the diseases of the two preceding periods might have proceeded from something in the air too subtile for our investigation, yet these few observations seem to be attended with so much probability as may at least suffice to shew the impropriety of neglecting the degrees of winds in journals of the weather: since, in judging of the constitutions of the air, or in tracing the causes of diseases from them, we cannot avail ourselves of these journals, when thus defective; but may be misled by them.

De Humoribus, sect. 11.—and Rhazes to the same purpose; Ventus autem a polo veniens meridiano, corpora dissolvit, sensus turbat, atque dolorem capitis et oculorum ægritudinem facit—febres itidem parit propter suam putredinem.—Est etiam plus omnibus ventis ægritudinem inferre paratus.—De ventis et aere, lib. 3. cap. 5.—This is the *austrina aeris constitutio* of the ancients, by which is frequently understood a warm and moist state of the air, though without winds of any kind. This constitution of the air, with its effects, is thus described by Hoffman: Certissimæ experientiz est, sub diuturna humidaque austrina aeris intemperie, præsertim ventis vacua, magnam ad putredinem morborum generationem proclivitatem fieri: unde frequentius videmus, præcedente paulo longius talismodi aeris statu, magno cum agmine prorumpere morbillos, catarrhales, malignas et petechizantes febres purpuratasque, &c.

F I N I S.

Fig. 1.

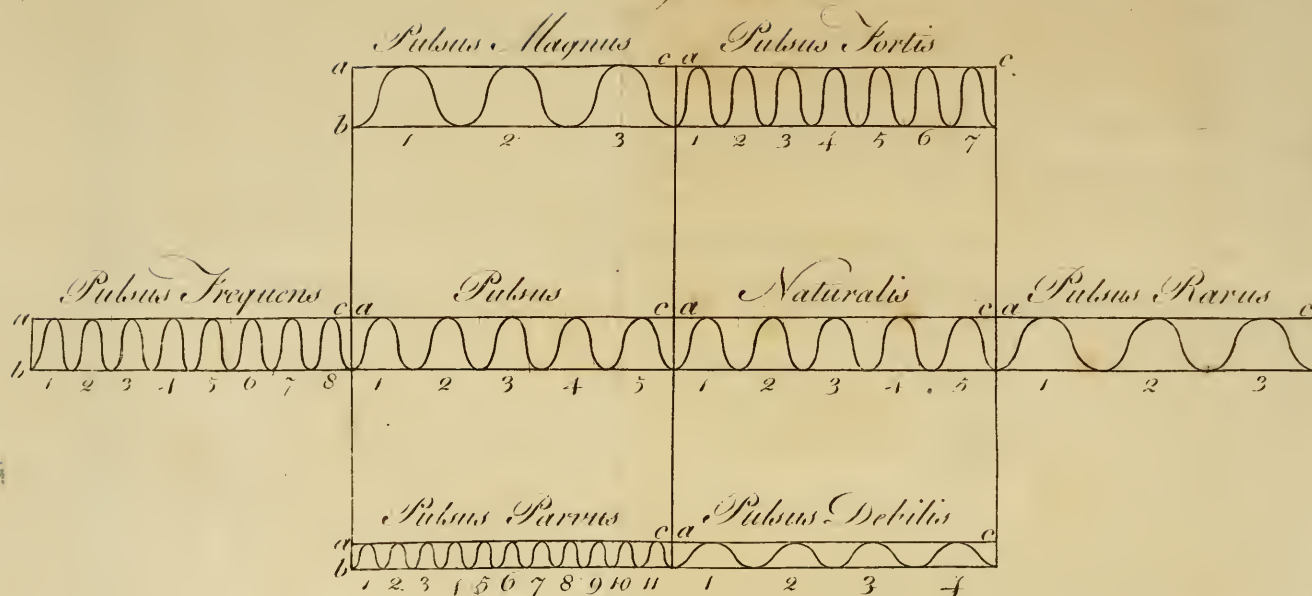
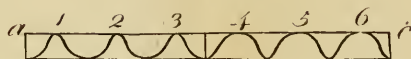
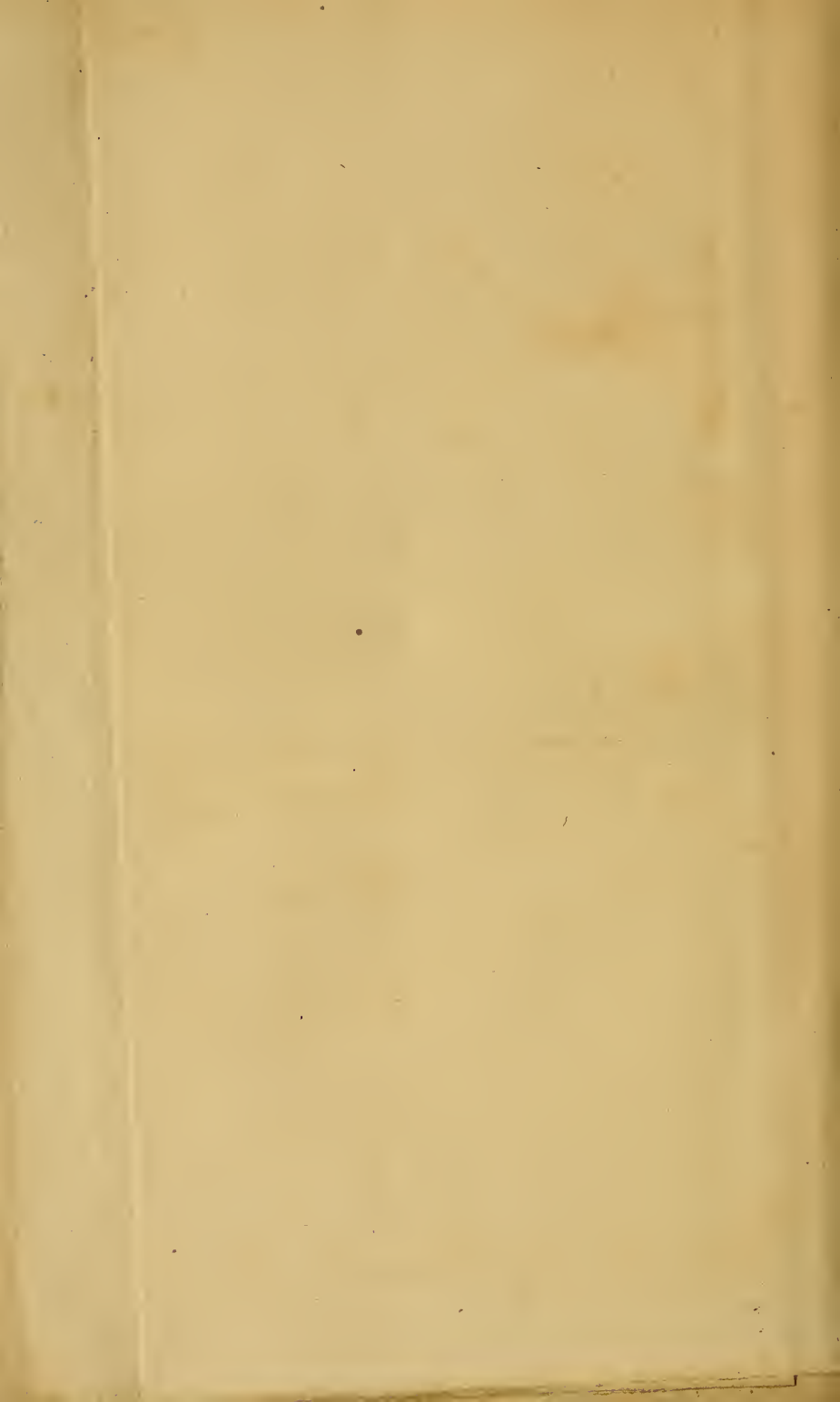


Fig. 2.





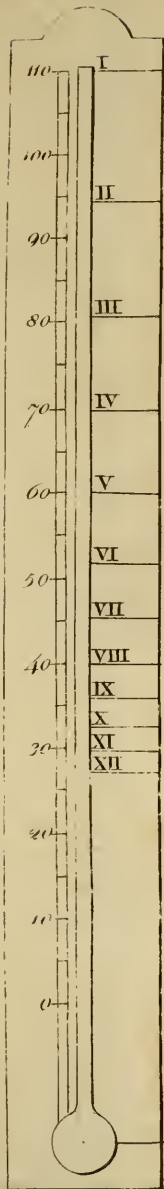


Fig. 2.

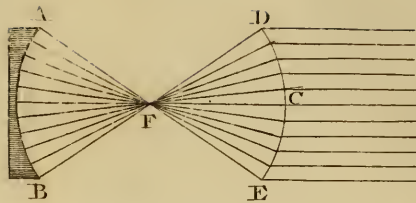


Fig. 3.



Fig. 1.

